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* indicates illustrated article.
§ indicates editorial comment.
‡ indicates communication.
† indicates a short non-illustrated article or note.

A

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Shop.

Steel Freight Cars, Maintenance and Repair of at Altoona, Pennsylvania Railroad.

THE PAGE NUMBERS FOR THE DIFFERENT MONTHS OF THE YEAR 1909 ARE AS FOLLOWS:

January	1-44	May	181-216	September	345-384
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DESIGN OF OIL BURNING LOCOMOTIVES.

Harrington Emerson.

A locomotive is an apparatus in which the heat evolved by the combustion of carbon, hydrogen and sulphur with oxygen is transferred to water in an enclosed receptacle, the water being converted into steam under pressure, which by its pressure and expansion drives the steam engine.

To a coal-burning locomotive there are two principal limitations:

(1) The ability of the draft arrangements to furnish sufficient air for combustion.

(2) The ability of the fireman to feed coal properly.

Draft.—The draft is created by the escape of steam. Exhaust steam is preferably used and the more work it does in making draft, the greater the back pressure. If live steam is used, to that extent the steam available for the engine cylinder is curtailed. It is evident that with very little draft there will be very little combustion and consequently very little available steam. If, however, all the steam is used to create a draft there will be none left over for power purposes. The problem, therefore, is to obtain the maximum of draft without using too much of the steam for this purpose. Of the power used for draft, one-third is consumed in drawing the air through the bed of coals, one-third in drawing the air through the tubes and one-third in the resistance in the front end, diaphragm, etc. Dratt, therefore, could be very much increased if there were no bed of coals, if there were no diaphragm and if tubes were larger, fewer and shorter.

The Fireman.—There is a limit to the ability of the fireman:

(1) To shovel coal.

(2) To shovel coal so as to reach the further parts of a large grate.

(3) To shovel coal so as to maintain an even bed of fire.

Even when the fireman shovels coal perfectly, if the furnace, the tubes and the front end are not of proper design, the results will fall off.

The draft is often so strong as to lift the bed of coals from the grate and to plug the small flues with big cinders. Very small flues would not do.

The combustion space above the bed of coals must be large enough to complete the combustion of the coal before the gases enter the tubes.

Perhaps the chief faults in the design of the large modern coal-burning locomotives are:

(1) The tubes have been unnecessarily lengthened beyond the length of maximum result, 13 feet.

(2) The fire box has not been enlarged sufficiently to provide an ample combustion chamber.

Nevertheless, modern coal-burning locomotives, both in Europe and America, are well designed and efficient power generators.

When it comes to oil-burning locomotives, every principle of correct power generation has been violated. Oil burning locomotives were not specially designed for oil, but are in fact nothing but coal burners with an oil-spraying nozzle substituted for the grate. It stands to reason that designs and dimensions suited for coal are not suitable for oil. The sole excuse for using a coal-burning furnace and boiler design for oil is that it seems economical to put an oil nozzle in a fire box and to call the locomotive an oil burner. Also when oil becomes scarce it seems cheap to remove the nozzle, put back a grate and rechristen the locomotive a coal burner.

When, however, it is considered that a coal-burning fire box may last from 8 to 15 years, and the same fire box racked by oil combustion will last only from 1 to 5 years, and must then be renewed at a cost of from $2,000 to $5,000, the economy of adaptation proves fallacious, especially as a suitably designed oil furnace and boiler would not prove as inefficient for coal, as a coal furnace is for oil.

The particular limitations which apply to coal burning apparatus do not apply to oil:

(1) Because the oil is pumped in or injected, the limit of the fireman's strength or skill is eliminated.

(2) The limit to the amount of fuel is the amount of air that can be supplied.

(3) As there is no bed of coals through which to draw the air, this source of friction falls away.

(4) As there is no need of a diaphragm or screen to catch cinders, the front end friction is also reduced.

(5) As a consequence of reduced friction a very much larger volume of air can be furnished for combustion than in a coal burner.

(6) This larger volume of combustion requires a larger combustion chamber.

(7) With coal burners the gases enter the tubes at a temperature of about 1,300 degrees F., which 13 to 20 feet away drops to 500 degrees F.

(8) In modern oil burners the temperature of the gases is 2,800 degrees as they enter the tubes. This high heat enormously and rapidly damages the flue sheet and tube ends.

(9) Temperature of escaping gases is no higher than in coal burners.

(10) Therefore in an oil burner more heat is transmitted through the fire box and through part of the tubes near the fire than in a coal burner.

(11) As no cinders are dragged into the tubes to clog them up, tubes could be made much smaller in diameter, probably not over one-half inch.

(12) Tubes could also be limited to the best length for maximum result, about 13 feet.

(13) Many tubes are now 22 feet long. These might be shortened to 13 feet, thus making available 9 feet, a large part of which could be devoted to enlarging the combustion chamber, and the balance to a steam superheating or feed water heating device.

(14) The water spaces around the fire box ought to be much larger and the 9 feet extra length available for combustion chamber will permit water spaces one foot in width without making combustion chamber too small.

(15) With tubes one inch or less in diameter, although only 13 feet long, there will be more tube-heating surface than with tubes 22 feet long but 2½ inches in diameter.

(16) These smaller tubes can be thinner and because the gases have been fully burned in the combustion chamber before reaching the tubes, there will be in operation less deposit of carbon. Carbon deposits are in any case removed by sand and more easily from small than from large tubes.

(17) In consequence of lessened air friction, greater volume of air, unlimited oil supply, big combustion chamber, lower temperatures of gases entering tubes, big water spaces, greatly increased fire box heating surface and tube heating surface for same sized locomotive, the oil-burning combination could provide steam abundantly and economically as to fuel, and operate at low repair cost for furnace and boiler even in the largest Mallet compounds.

THE USE OF WOOD IN BUILDING CONSTRUCTION

Great as the advance in fireproof construction has been during the last ten years there has been no let-up in the use of lumber, and both architects and builders find themselves so dependent on wood to-day that they are compelled to admit that the forests of the country are likely to be the chief source of building material for many years to come.

"The use of cement, terra cotta, brick and stone, with a framework of steel, will make it possible soon to do away with wood entirely," is a remark often heard. As a matter of fact, the popular idea that fireproof materials will do away with the need of using lumber in a comparatively few years is a very erroneous one. All of the various fireproof materials going into the approved construction of the more substantial buildings are used in greater quantities now than the world dreamed of a few years ago, yet the heavy demand for lumber continues.

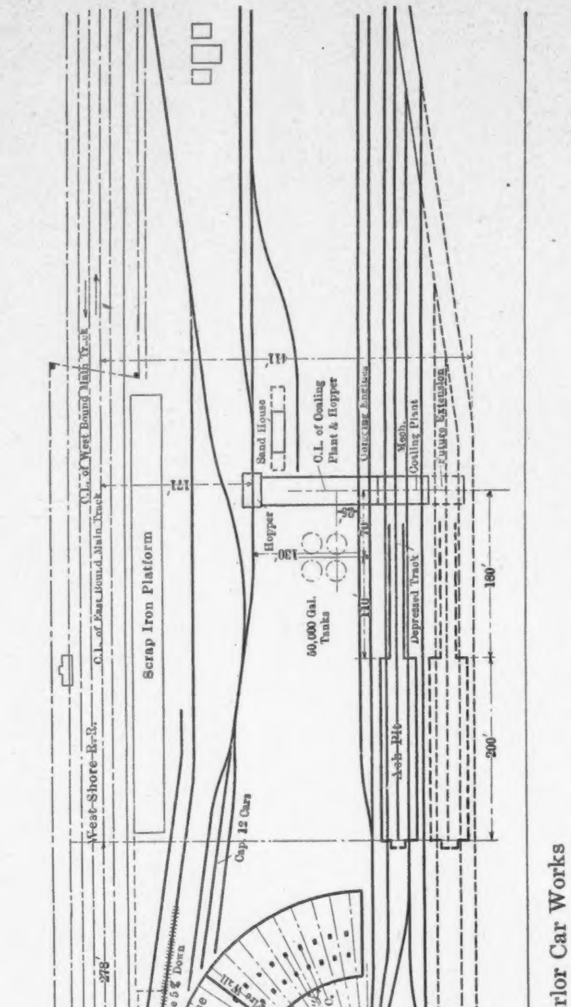
That wood predominates is shown by the annual building records. Of the permits used for buildings erected last year, approximately 61 per cent. were constructed of wood, and the remaining 39 per cent. of fire-resisting material, according to a report issued by the Geological Survey on operations in forty-nine leading cities of the country. These figures are the more significant when it is realized that they only represent the building activities in the largest cities; they do not take into account the construction of dwellings, stores and other buildings in the thousands of small cities and towns scattered over and not included in the forty-nine cities on which the reckoning is made.

In towns and small cities wood is usually the predominating building material and it is safe to say that if the statistics had included figures for all places of whatever size, the percentage of wooden construction would have been much greater.—*From a report of the Forest Service of the U. S. Dept. of Agriculture.*

THE IMPORTANCE OF KNOWING COSTS PROMPTLY.—The accounts showing what is actually spent each day must be in the hands of those in control as soon as possible after it is spent; not a month's nor a week's report at a time, but a day's report at a time, and it must be in the possession of the officer or man in charge of the expenditure as soon as possible. The section foreman must know at the close of to-day what he has spent to-day. The same is true of the shop foreman. The supervisor should know to-morrow what has been spent by his section foreman to-day.

At first thought it may seem that this would involve an immense amount of bookkeeping and complication of accounts, and consequently a large additional force of men. This, however, is not so. It does not involve the putting on of any additional men, as this daily check can be carried out by the present force without difficulty, as the necessary accounts are so simple and are kept by so many that it puts but little work on each, and in the larger offices, such as the division superintendents and master mechanics, it means but a consolidation of figures. This is no theoretical or fanciful scheme whatever, but is a definite practice which has been in actual operation for sufficient time to thoroughly demonstrate its practicability. It simply means system in expending the money for operating expenses and adapting to the railroad business the same rules as to knowing and watching cost that apply to all other lines of business.—*W. J. Harahan, before the New York Railroad Club.*

FREEZING OF AIR BRAKE HOSE.—The reason that air brake hose gets hard in cold weather is generally due to freezing. If we could get some kind of rubber that would not freeze we would be very happy. Crude rubber will freeze at about 20 degrees F., and vulcanized rubber freezes at about zero. All rubber companies have experimented in different ways to prevent this, and they have added oils and all kinds of things that do not freeze so readily, but in this country the temperature gets so low that it frequently gets beyond us.—*A. D. Thornton, general technical superintendent, Canadian Rubber Company, before the Canadian Railway Club.*



GENERAL PLAN OF THE NEW ENGINE HOUSE PLANT AT EAST BUFFALO, NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

EAST BUFFALO ROUNDHOUSE.

New York Central & Hudson River Railroad.

A new 30 stall roundhouse for passenger locomotives has recently been placed in operation by the New York Central & Hudson River Railroad at East Buffalo. It lies between the West Shore Railroad tracks and the Pullman Parlor Car Works, near the old 28 stall roundhouse of the West Shore Railroad.

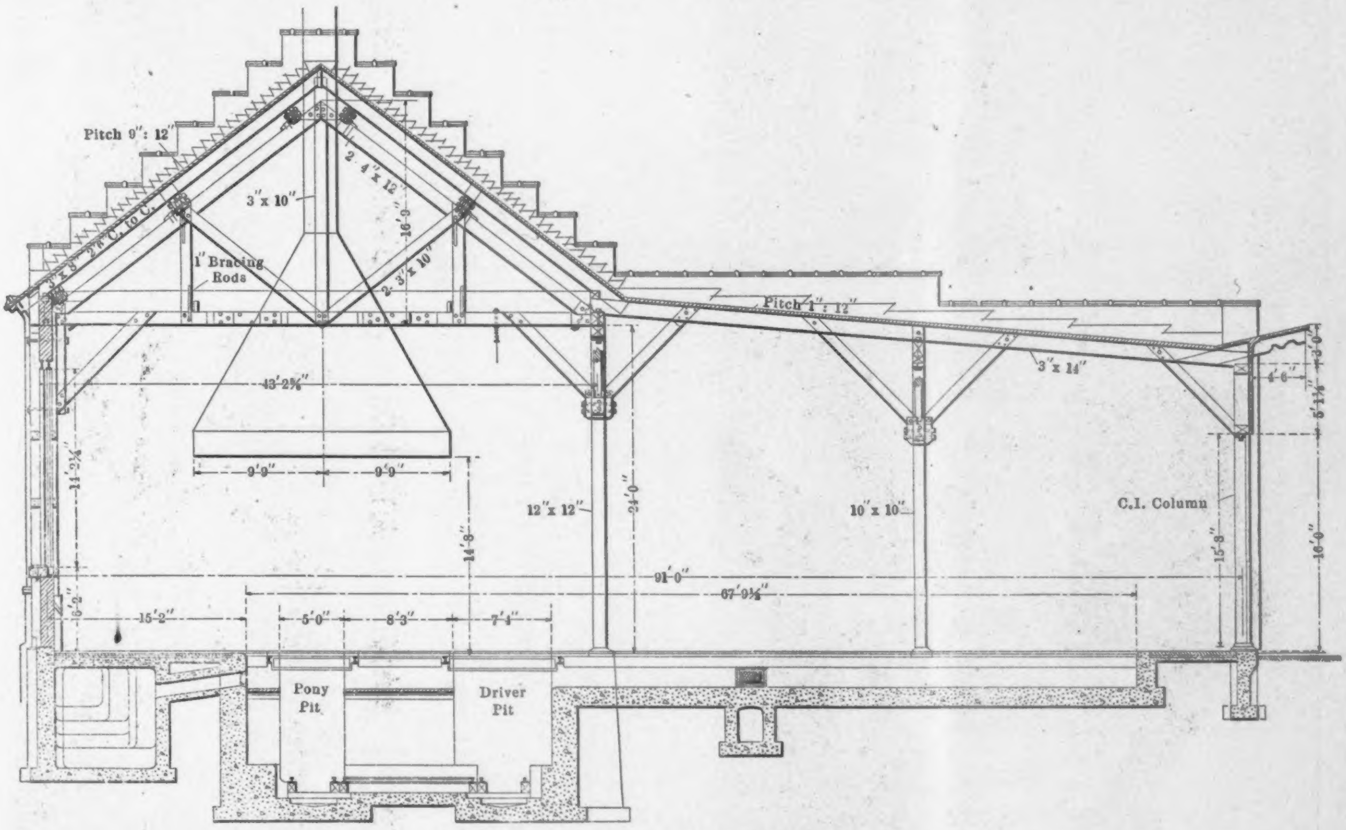
General Arrangement.—As shown by the dotted lines on the general plan, provision has been made for the addition of a 50 stall roundhouse to meet future requirements; also for additional ash pits and water tanks and for the extension of the coaling station and the power plant.

Engines enter the plant from the east, on one of the incoming tracks, and take coal and sand, after which they move forward and take water and then move on to the ash pits. The coaling station is about 650 ft. from the turntable and the standpipes are a sufficient distance from the coaling station so that one engine may take water while another is coaling on the same track. Coal for the power house is brought in over the track at the north, the cars unloading into coal bins from a trestle. Coal for the coaling station is also brought in on the track at the north and may be stored on the three tracks just east of the roundhouse. These tracks are on an incline and, as the coal is needed, a car may be started down the grade with the aid of a pinch bar and be stopped over the hopper, into which it is dumped and from which it is elevated to the storage bins above the tracks. The sand, after being dried in the sand house, is elevated to storage tanks in the coaling plant by compressed air.

The tracks over which the coal and sand are brought in do not in any way interfere with the incoming and outgoing tracks for the engines; the only place where there is liable to be any interference is in connection with the cinder cars from the ash pit and this can readily be guarded against. Ordinarily the engines come in and go out at the eastern end of the plant but provision has been made so that in case of emergency engines may be taken out at the western end over the track which separates the main portion of the engine house from that part containing the drop pits, machine shop and offices.

The Roundhouse.—The main portion of the roundhouse, consisting of 26 stalls, is divided by two fire walls, with steel fire doors, into three portions. The drop pit section contains three stalls, and the machine shop, which has a common wall with the drop pit section, has a pit which may be used for engines requiring light repairs. Two of the pits in the main portion of the house are equipped with a drop pit for engine truck wheels. The building has a depth of 90 ft., measured from center to center of the wall columns and the distance from the center of the turntable to the inner wall of the house is 130 ft. 1¾ in. The tracks radiate at an angle of 5 deg. 44 min. 52 sec. from the center of the turntable.

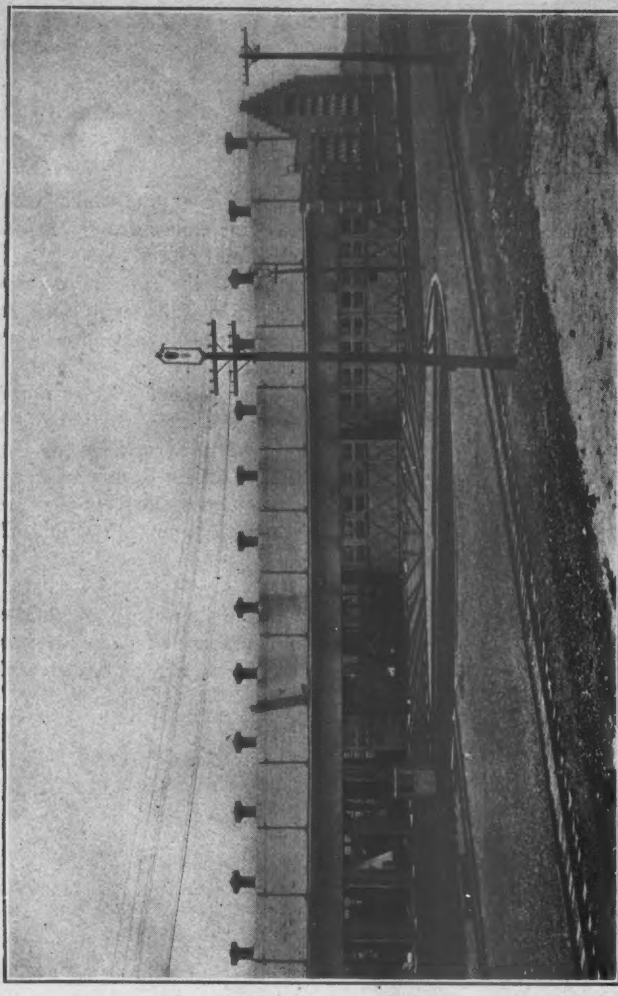
The foundation, pits and floor of the house are of concrete and the walls are of brick. The columns are of yellow pine, of the dimensions shown, and the roof trusses are of timber. The roof consists of 2 in. timbers upon which "Special Brooks Brand" roofing, furnished by the H. W. Johns-Manville Co., is laid.



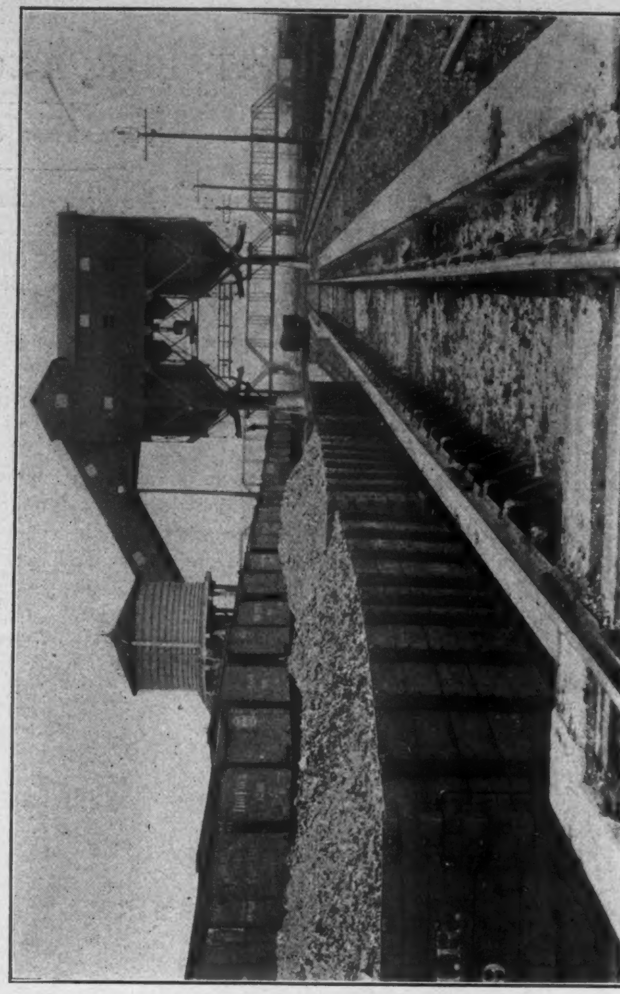
CROSS-SECTION THROUGH THE DROP PIT SECTION OF THE ROUNDHOUSE.

The most noticeable feature of the house is the large amount of window space, which furnishes splendid day-lighting, and the amount of head room. The wall above the windows is supported by two 9 in. I beams, which extend crosswise above the windows. Wooden doors are used; they are held in an open position by bolts which fit in sockets in concrete piers, about 2 ft. square in section.

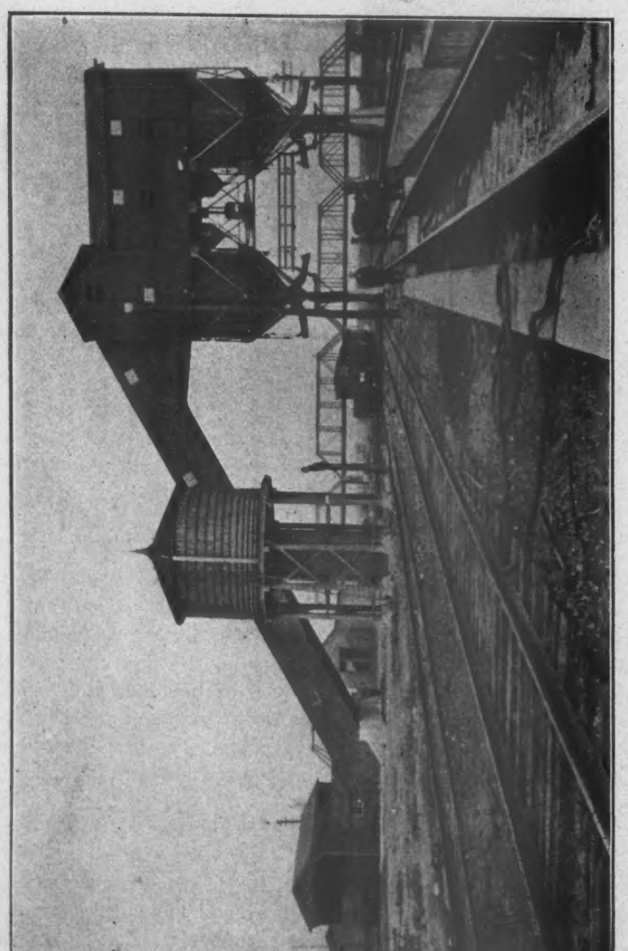
The cross-sectional view of the house shows a section through the drop pits. The pits in the main part of the house are 67 ft. 9½ in. long, extending to within 8 ft. ½ in. of the outer wall. They are 3 ft. 4 in. deep at the inner end and 2 ft. 8 in. deep at the outer end. A 15 in. jacking timber is placed alongside the rails of each pit.



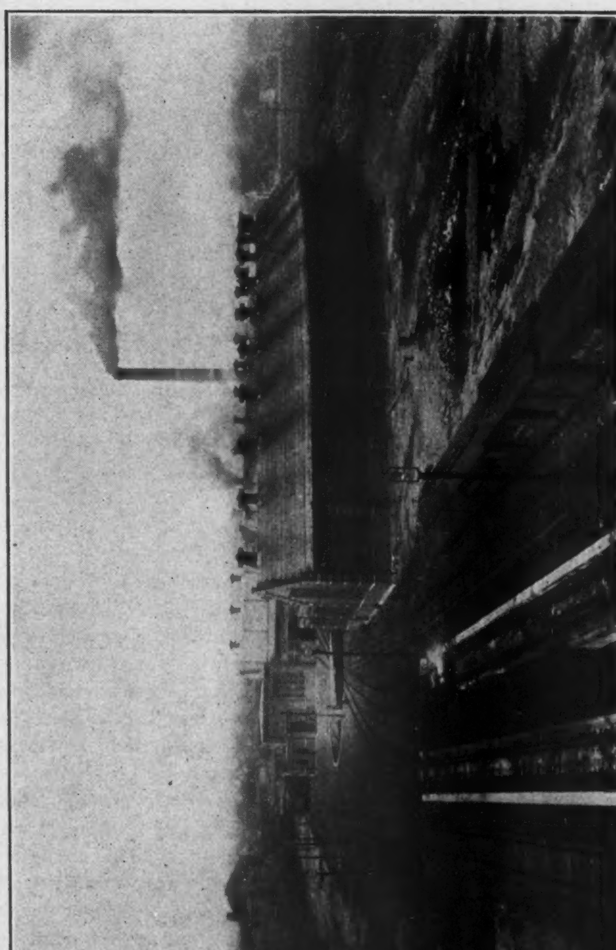
PARTIAL VIEW OF THE END OF THE ROUNDHOUSE NEAREST THE COALING STATION.



CINDER PIT AND COALING STATION.



COALING STATION. CINDER PIT TO THE RIGHT



VIEW OF THE ROUNDHOUSE FROM THE COALING STATION, CINDER PIT IN THE FOREGROUND.

Smoke Jacks.—The smoke jacks are of a new type, known as the "Phoenix," furnished by the H. W. Johns-Manville Co., of New York. They are fire and acid proof, being made of a compound of asbestos and magnesia, reinforced by galvanized iron cloth, which is imbedded in this material. The material and the moulds were shipped to the roundhouse and the jacks were moulded on the premises in three pieces—the hood, circular part or stack, and the cowl. The plastic material sets hard in a few hours, after which it is very hard and durable and is not affected by fire, acids or moisture.

The jacks are supported by rods which are attached to lugs on the hood. These lugs, which are moulded on the hood, are reinforced by heavy wire cable, the ends of which are unraveled and interwoven with the wire cloth. After the jacks were installed the supporting rods were covered with the "Phoenix" material to prevent deterioration. The interior of the jack is smooth, having no protruding bolt heads or flanges. The average thickness of the material is ⅝ in. and it weighs from 4 to 4½ lbs. per square foot. The jacks shown on the cross-sectional view, over the drop pits, have a hood 19 ft. in length at the bottom, but in the main part of the house this length is only 8 ft. They are 4 ft. wide.

Locomotive Boiler Water Changing and Washing Out Equipment.—The W. L. Miller Heating Company's system for changing the water and washing out the locomotive boilers is used. The piping for this system, as well as the air pipes and the live steam pipes for blowing purposes, are carried overhead and have branches extending downward alongside the columns between every other pit. The live steam and hot water pipes are covered to prevent radiation. The Miller heating system consists of a 3 in. hot water pipe, a 4 in. cold water pipe, and a 6 in. blow-off pipe. There is a mixing box and a connection for attaching two hose lines on the columns between every other pit In the section of the power house containing the heating fans are two large tanks, one above the other, in which the water for washing out and filling the boilers is heated from the exhaust steam from the locomotive boilers, when they are emptied. The larger of the heating tanks is 22 ft. 10 in. long over the heads and 72 in. inside diameter; the inner one is 18 ft. long and 48 in. inside diameter.

This system is guaranteed to give the following results: When water and steam at about 190 lbs. pressure are blown from the locomotive boiler, sufficient fresh water at 55 degs. F. will be heated to 195 degs. F. to fill a similar locomotive boiler to the same level without the use of any steam or hot water, except that supplied by the first boiler and the exhaust steam from the water pump. When water and steam at about 190 lbs. pressure are blown off, sufficient fresh water at 55 degs. F. will be heated to 125 degs. F. to thoroughly wash out a locomotive boiler of the same size. The time required for this operation should not exceed 2 hours. The same operation may be performed on two adjacent pits without affecting the above results.

Heating System.—The heating fans are contained in the section of the power house nearest the roundhouse and connected to it by a passageway. Hot air is forced into a duct, or tunnel, which extends around the outer circle of the house. This tunnel is of concrete and is 9 ft. 6 in. wide by 7 ft. deep where it enters, tapering gradually as it extends to either end of the house. Between every other pit a conduit, 36 in. in diameter, leads from the main duct and from either side of this three 18 in. ducts lead to the pits; two of these ducts enter the pit near the ends, and the other one near the middle. The 36 in. duct gradually decreases in diameter, ending in a 10 in. duct which extends upward and opens into the house at the column alongside the doorway. These openings, as well as those leading into the pits, are fitted with dampers. The branch ducts, where they lead from the main tunnel, are equipped with deflectors, so that under normal conditions the same amount of air is delivered to each pit. Pipes, 5 in. in diameter, extend upward, from the main tunnel, underneath the windows at the outer wall of the house and have at the upper ends a T into which perforated pipes 5 in. in diameter, with caps at the ends, are fitted. The upper member of the T thus formed is 9 ft. in length and has several 1¼ in. perforations in the top side, spaced 6 in. apart. A 33 in. galvanized iron pipe extends upward from the end of the heating duct and into the machine shop; branches lead off from it, directing the heated air downward, thus heating this part of the building.

The heating system was installed by the Buffalo Heating Co. and is guaranteed to maintain an even temperature of 65 degs. F. when the external air is 10 degs. below zero, and when fresh air only is supplied to the fans. It is guaranteed to maintain the same temperature inside when the temperature of the external air is 20 degs. below zero and 25 per cent of the air taken into the heater is from the inside and is recirculated. The temperature of 65 degs. F. is to be obtained after the doors leading from the turntable have been closed five minutes. It is also expected that the house will be kept clear of fog and steam. The fans have a capacity for changing the entire contents of the house every eight minutes, and of the annex every fifteen. Steam for the heating coils is furnished at a pressure of 1 lb. or less.

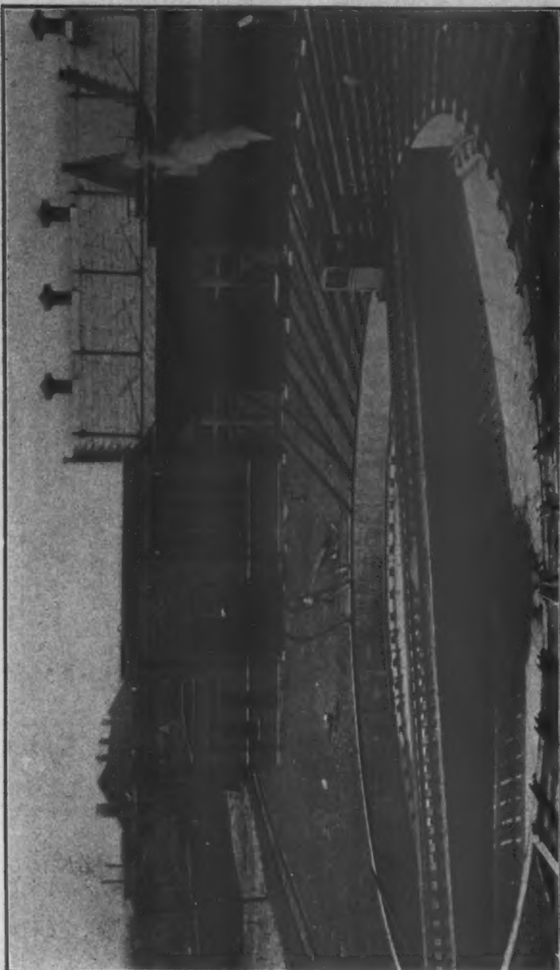
The heating coils consist of two systems of inverted U shaped coils, constructed with two groups in each system. These

SMOKE JACKS. ALSO SHOWS THE PIPING USED IN CONNECTION WITH THE BOILER WATER CHANGING AND WASHING OUT SYSTEM.

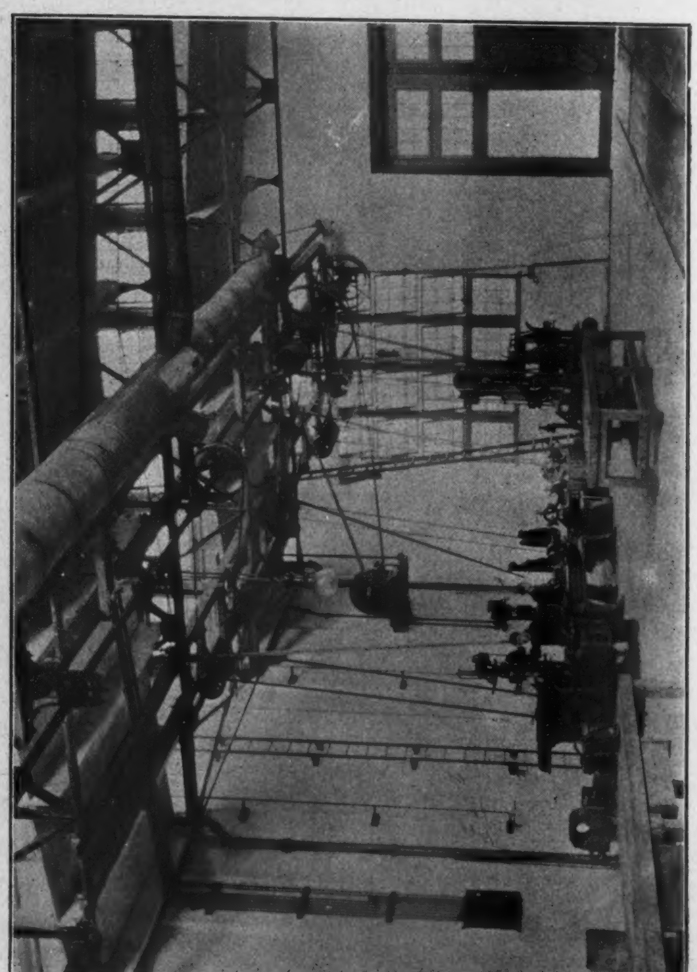
groups are arranged in four divisions, so that the amount of heating surface may be varied to suit conditions. The heaters contain an aggregate length of 14,000 actual lineal feet of 1 in. pipe. The free area in any row of coils is not less than 40 per cent. of the total cross-section through the row nearest the point of admission of cold air. The fans are of the three-quarter housed, steel plate type and have a capacity for delivering 88,000 cu. ft. of air per minute, with a pressure of not less than ¾ oz. at the discharge orifice, and when operating at 140 r. p. m. The fans are driven by 14 x 14 in. direct connected horizontal steam engines, using steam at 80 lbs. pressure and having an indicated horsepower of 52, with a back pressure of not less than 1 lb. and cut-off at half stroke.

Lighting.—The large amount of window space in the outer walls of the house furnishes splendid day-lighting. The electrical power for artificial lighting is furnished by the Niagara Falls Power Co. An Edison two-three wire system provides alternating current at 60 cycles and 104 and 208 volts. A multiple

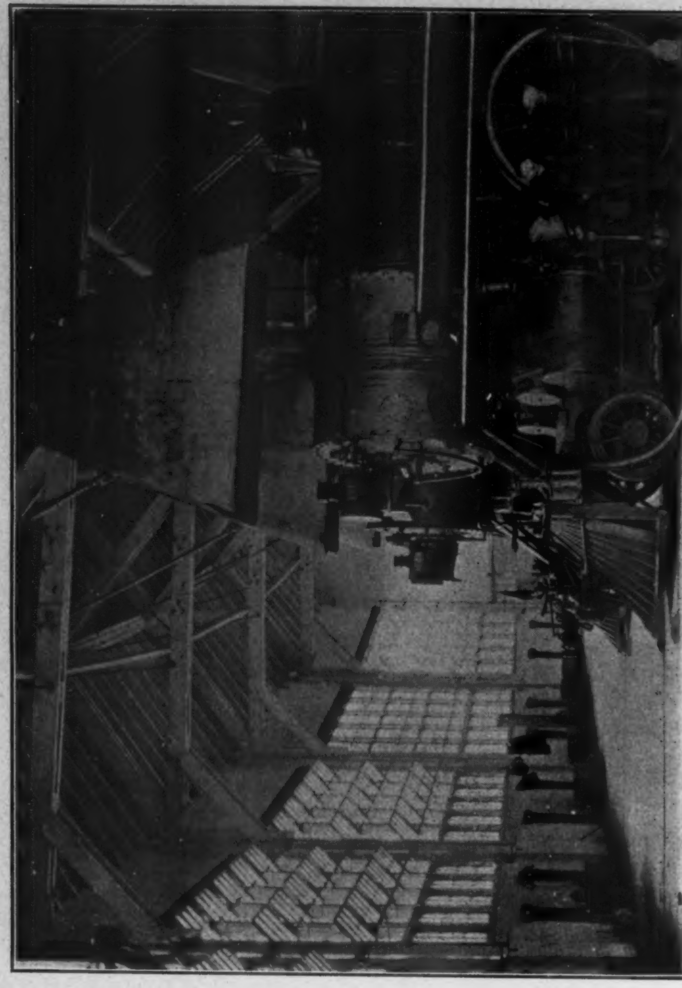
OFFICES AND MACHINE SHOP.



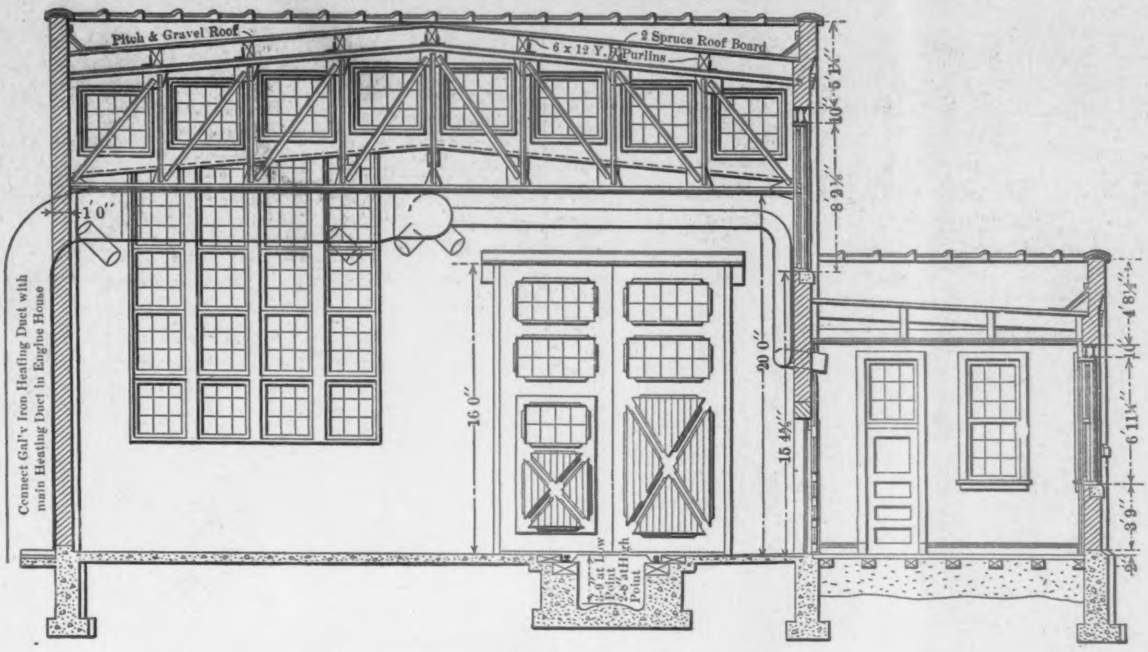
TURNTABLE. ALSO A VIEW OF THE OFFICE—MACHINE SHOP—DROP PIT SECTION OF THE HOUSE.



INTERIOR OF THE MACHINE SHOP.



INTERIOR OF THE ROUNDHOUSE.



CROSS-SECTION THROUGH THE MACHINE SHOP AND OFFICE.

enclosed type arc lamp, for six amperes at 110 volts, is suspended between the stalls, except at the ends and at the fire walls. A portable outlet, snap switch and two incandescent lights are placed on each side of the fire walls and at the end walls, and a snap switch and cutout control each pit light circuit. Recesses are placed in the drop pits for incandescent lights. All the wiring is carried in loricated iron conduits.

Equipment.—At the head end of each pit an iron block or stop is fastened to the track and prevents the locomotive from running into the wall. It is also the practice to place a heavy chain on the track in front and behind of one of the drivers, so that if for any cause the throttle should accidentally become opened, or leak, it would be impossible for the engine to move out of place. The machinists have portable tool boxes, which are about 3 ft. long, 18 in. wide and 13 in. high and are fastened upon trucks, so that they can easily and quickly be moved to any part of the house. There are also two or three portable vises, which are fastened on trucks. The boiler washer's tools and hose reels are carried on trucks. One of the illustrations shows the simple and substantial method by which a vise bench is fastened to the wooden columns. The table upon which the vise is placed is of cast iron, 20 x 30 in. x ⅛ in. in size and about 30 in. above the floor. The vises are the No. 6 size made by the Howard Iron Works.

At about the center of the middle section of the house, against the wall of the outer circle, is a tool room, 8 by 13 ft. in size. Here all of the heavy and special tools are kept, the mechanics drawing them as they are needed and returning them as soon as the job they are working on is finished. The jacks are stored just outside this room and are locked after and kept in good condition by the man in charge of the tool room.

Drop Pits.—That section of the house, consisting of three stalls adjacent to the machine shop, is entirely separated from the main part of the house and is equipped with two drop pits extending under all three tracks, one for driving wheels and the other for truck wheels. These drop pits are 8 ft. 3 in. apart and are connected by three passageways, one of which has a track with a turntable at each end, so that the trucks carrying the telescopic jacks can be transferred from one pit to another. The driver pit is 7 ft. 4 in. wide and the pony or truck wheel pit 5 ft. wide.

In removing a pair of wheels from an engine the pedestal binders are taken down and the rods disconnected. Jacks are placed under the engine frame. The telescopic jack is placed underneath the middle of the axle and the drivers are raised sufficiently to allow the 10 in. I-beams, to which the rails are bolted, to be pulled aside. The wheels are then lowered into the pit. A 6 ton electric hoist will be installed over the drop pits. There is also a pony or truck wheel drop pit extending under two tracks in the main part of the roundhouse, as shown on the plan view.

Machine Shop.—The machine shop is adjacent to the drop pit section of the roundhouse, having a common wall with it. It is 40 ft. wide inside, 102 ft. long, and has a concrete floor. Along the side nearest the offices is a pit upon which light repairs may be made. The remaining portion of the shop is used for machine tools and a forge and anvil for the smith. The construction of the roof, which is supported by light steel trusses, is shown in the cross-sectional view of this shop, and on the photographs, and furnishes a plentiful supply of daylight. The machine tools are driven by a 40 h.p. alternating current motor, which is mounted on a wall bracket. At the present time the following machine tools are in use:

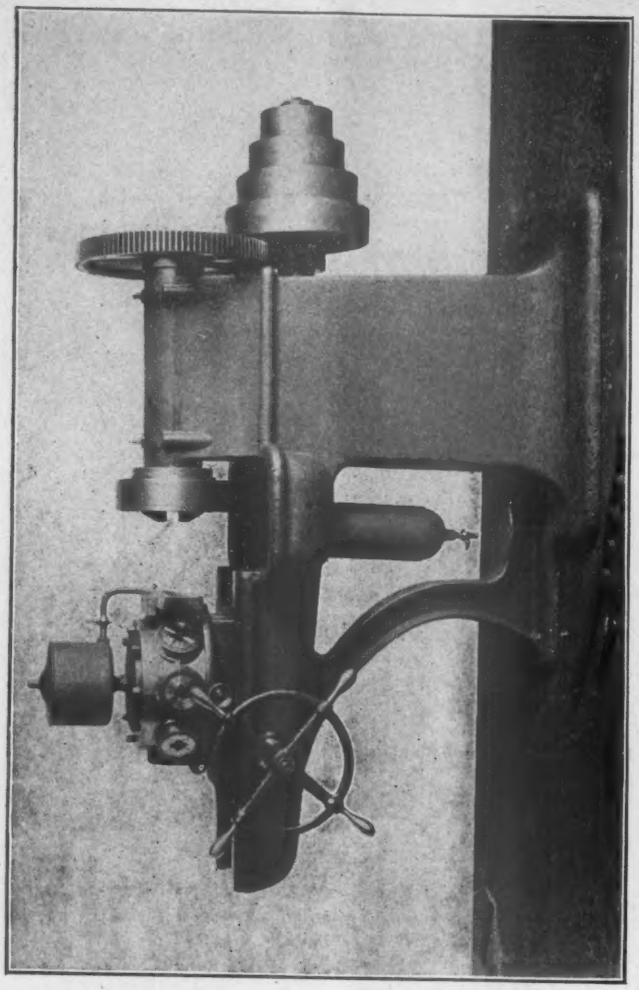
Lathe, Putnam Machine Co.
Small Drill Press, Bement-Miles & Co.
Shaper, Gould & Eberhardt.
Bolt Cutter, Acme.
Turret Bolt Cutter, No. 4, Pratt & Whitney.
Grinder, Bridgeport Safety Emery Wheel Co.
Drill Press, Cincinnati Machine Tool Co.
Boring Mill, Two Head, Bullard Machine Tool Co.
Lathe, McMahon & Co.

There is also a forge, with a stack to carry off the smoke and gases, and an anvil. A crane will be installed to serve the heavier machine tools.

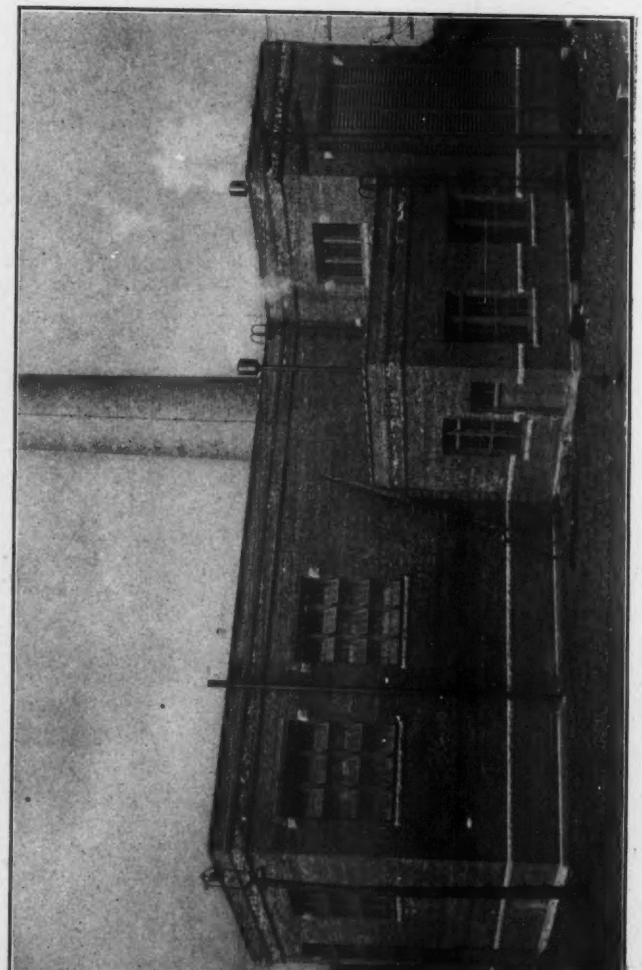
The Pratt & Whitney No. 4 turret head bolt cutter has a revolving head carrying nine dies, any one of which may be presented instantly to the bolt to be cut. The turret is secured in position by a spring lock-bolt. The spindle is hollow to receive bolts of any length and by removing the die, opposite the one that is at work, allowing the bolts to project through the turret, the thread may be cut any length required. The spindle is equipped with a chuck for holding the bolt or tap and is driven by a cone pulley. The chips and oil are caught in the bed and the oil drains free from the chips through a strainer into a receiver, from which it may be drawn and used again. As the machine is fitted with nine different dies, this many different size bolts may be threaded almost as quickly as the same number of one size. Such a machine is especially valuable in a roundhouse, where the number of bolts of one size, to be cut at one time, is small and where changes of size are frequent. The machine is furnished with two nut plates and one nut plate holder, and the following sizes of taps and dies, ½, ⅝, ¾, ⅞, 1, 1⅛, 1¼, 1⅜ and 1½.

Offices, Rest Room and Toilet.—A small addition to the machine shop, 16 ft. wide and about 59 ft. long, is divided into four parts, two of the rooms, with wooden floors, being used as

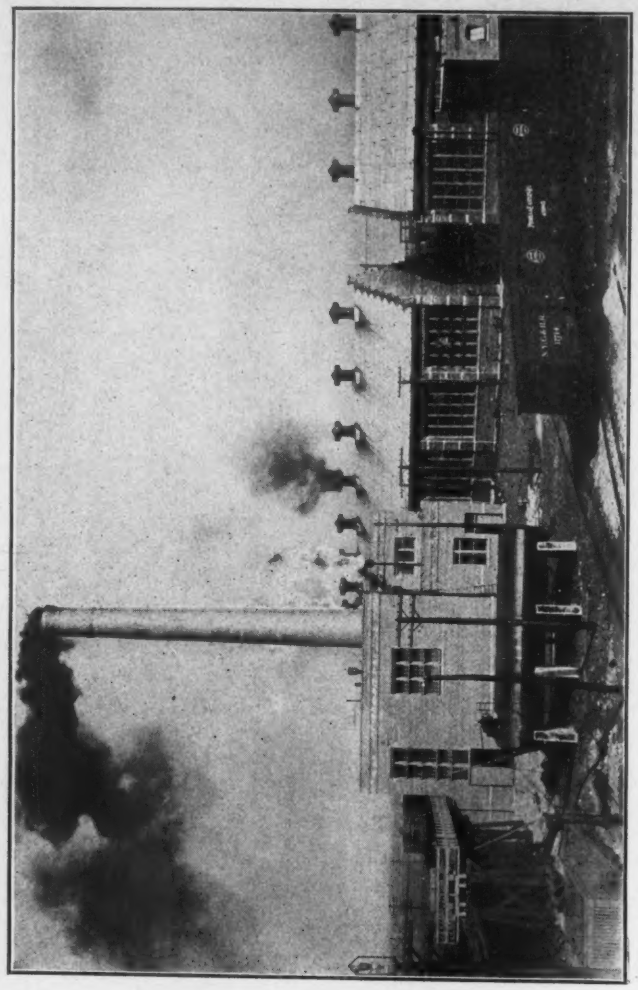
VISE BENCH ATTACHED TO WOODEN COLUMN.



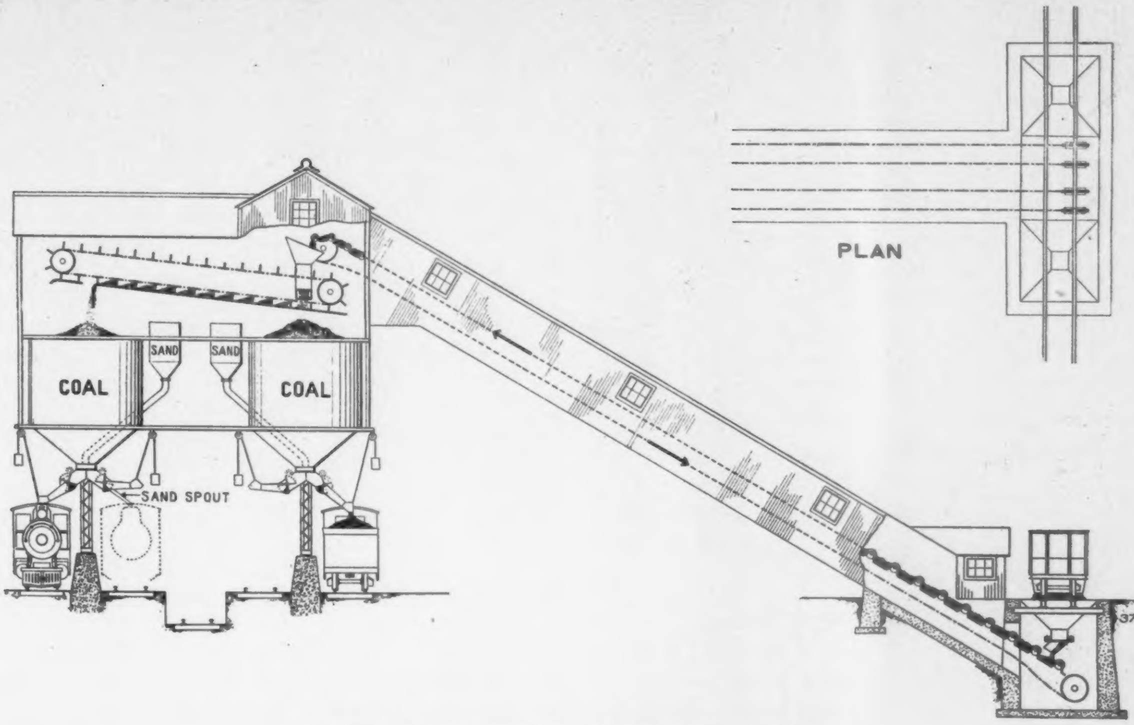
PRATT & WHITNEY TURRET HEAD BOLT CUTTER.



POWER HOUSE.



OIL STORAGE TANKS, POWER HOUSE AND A PORTION OF THE ROUNDHOUSE.



GENERAL ARRANGEMENT OF THE COALING STATION.

offices. The toilet and wash room has a concrete floor and is equipped with iron fixtures furnished by the J. L. Mott Iron Works. The rest room is furnished with a bench around two sides and may be used by the workmen while eating their lunch, or when off duty. A railroad Y. M. C. A. building is located only a few blocks from the roundhouse and is very convenient for the engine crews.

Turntable.—The turntable is 85 ft. long and was built by the King Bridge Company, of Cleveland, O. The pit is of concrete construction. The table is driven by electric power. The electrical controlling apparatus is enclosed in a small house, which is heated and lighted by electricity. A hand brake and sanding apparatus are also provided.

Coaling Station.—The coaling station consists of two circular pockets constructed of ⅜ in. steel and having a storage capacity of 300 tons. The flow of coal from these tanks to the tenders is controlled by under-cut gates. The conveying apparatus and the storage tanks are covered by a monitor, consisting of a steel frame-work covered with corrugated galvanized steel. The two smaller tanks shown between the larger ones are used for sand. As shown on the general plan, the coal is stored on three tracks near the engine house. As occasion requires the cars are moved down the slight incline and over the hopper, which is covered by a structure 14 ft. wide and 40 ft. long. The coal is unloaded into the hopper, and from this a reciprocating feeder feeds it in regular and uniform quantities to the conveying apparatus.

The conveying apparatus is furnished in duplicate, each unit having an elevating capacity of 100 tons per hour. This apparatus, extending from the feeder to above the first storage tank, measures 127 feet between centers and is placed at an angle of 30 degs. with the horizontal. A horizontal conveyor is used for carrying the coal from the inclined conveyor to the storage hoppers. These conveyors are driven by alternating current motors, operating on 3-phase, 25 cycle, 440 volt service The plant is heated by steam and lighted by incandescent lights. It was designed and installed by the Link-Belt Company, of Philadelphia.

Sand.—The sand house is 55 ft. long by 15 ft. 8 in. wide and is located near the hopper house of the coaling station. The sand is shoveled into the storage space in the house and from there is wheeled up an incline in barrows and dumped above the sand stoves, of which there are two. As it dries it drops into a pit and is fed into tanks, 3 ft. in diameter. It is forced from these tanks to the storage tanks in the coaling station, through 2½ in. extra heavy pipe, by compressed air. The storage tanks above the tracks have a capacity for 190 cu. ft. of sand.

Water Supply.—At the present time there is a 50,000 gallon tank which supplies the water columns. As the plant is extended it will be necessary to add additional water tanks, as indicated. The location of the water columns is shown on the general plan.

Cinder Pits.—There are two cinder pits, each 200 ft. long, with a depressed track between them. The pits are 26 in. deep and the cinders, after they have been wet down, are shoveled from these into gondola cars. The pits are of concrete construction and the rails are carried on cast iron chairs, as shown in the illustration.

Store House.—The store house is 61 ft. 4 in. in length and 30 ft. 8 in. wide. The platform, on two sides of it, is of paving brick, laid herringbone, with a concrete curbing. The building is a steel frame brick structure with concrete floors and fireproof roofing. The doors are covered with metal and the windows are wire glass in galvanized iron frames. One end of the storehouse, about 34 ft. in length, is used for oil and waste, and the other, and smaller part, is used for the storage of other supplies.

In the oil room are four large oil tanks. The oil is unloaded from the cars in barrels, which are rolled across the platform and into a frame work, or basket, shown in the accompanying illustration. This is then raised by means of an air hoist, which is attached to the roof beams inside of the building. When the basket, or frame work, is flush with the opening the barrel rolls by gravity into the building and onto a gallery above the oil tanks; it is then discharged into these tanks by gravity. Kerosene and fuel oil are stored in two large tanks west of the power house, each having a capacity of 10,000 gallons. These are supported on concrete piers and are connected by pipes to the oil house, being high enough so that the oil flows to the house by gravity.

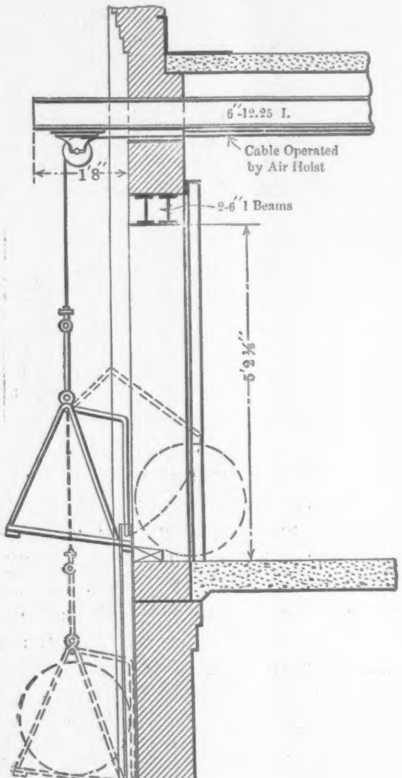
Power Plant.—Mention has already been made of that part of the power house which contains the heating apparatus and the equipment for the boiler water changing and washing out system. This part of the building is 51 ft. 6 in. wide by 67 ft. long, except that one corner is cut off and a passage way extends from it to the engine house. It also contains an air compressor, of the Ingersoll-Rand, class H, type, having 16 x 16 and 26 x 16 in. steam cylinders and 16¼ x 16 and 25¼ x 16 in. air cylinders.

Connected to this portion of the building is a pump room, about 25½ ft. square, which contains the fire and service pumps.

The Underwriter's fire pump has a capacity for 1,000 gallons per minute, or four good 1⅛ in. smooth nozzle streams. There are two M. T. Davidson Co., 14 x 8¼ x 14 in. service pumps.

The remaining portion of the building consists of a boiler room, 66 ft. long and 43 ft. 6 in. wide. It contains three 200 h. p. Heine Safety Boiler Company boilers, with space for an additional unit if it should be required. The boilers are designed for 180 lbs. working pressure and are equipped with McClave shaking grates. The feed water heater is the No. 3 size made by The Platt Iron Works Co., Dayton, O. A Worthington 7½ x 4½ x 10 in. feed pump is used.

Along one side of the boiler room are the coal and ash rooms.



DEVICE FOR ELEVATING OIL BARRELS AT THE STOREHOUSE.

The coal is brought in over these rooms by means of a 16 ft. trestle, with a 5 per cent down grade, and is dropped into them by gravity. That part of the trestle leading to the building is supported by timbers resting on concrete piers. The track above the coal and ash rooms is supported by concrete piers, 3 ft. in section and spaced about 16 ft. apart.

The radial brick chimney, 125 ft. high, 12 ft. 4 in. in diameter at the base and 7 ft. 2¼ in. in diameter at the top, was built by the Alphons Custodis Chimney Construction Company, New York. It has a capacity to supply draft for boilers aggregating 800 h. p. and is fitted with an automatic draft regulator.

Correspondence.—Correspondence should not be shifted around simply to relieve desks of the presence of papers, but it should be thoroughly gone into, all questions answered, and, if an answer naturally develops another question, it should also be answered. It is exasperating to receive returned papers in which all questions are not answered, in an effort evidently to easily get rid of the correspondence, and such methods are insensibly treasured against those performing such indifferent service. It should be the pride of a man conducting correspondence to feel that his superior officer did not have to return it for additional facts, if such additional facts could have been reported on in the first instance by a conclusive investigation. Where possible and consistent, definite recommendations should always be made, otherwise a man's office becomes but a clearing house for correspondence, and such clearing houses are not essential or even desirable.—*W. J. Harahan, before the New York Railroad Club.*

A GOOD MIXTURE FOR CASE HARDENING.

John Buckley, foreman blacksmith at the Burnside shop of the Illinois Central Railroad, uses the following mixture for case-hardening. It gives splendid results and is much less expensive than the method in use at many shops:

Take charcoal broken fine, about one inch in size. Put a two-inch layer of this in the bottom of the box and pack it down with a mallet. Sprinkle about one pound of common salt over the charcoal, one pound of pulverized sal soda over the salt, one pound of pulverized rosin over the sal soda, and one pound of black oxide manganese over the rosin. Lay the material to be case-hardened on this, taking care not to have the pieces too close together nor too close to the sides of the box, where metal boxes are used. Fill in between the pieces with charcoal and pack well, taking care to have about two inches of charcoal between the work to be case-hardened. Repeat the sprinkling of compounds over the second layer of work, the same as in the bottom of the box. Finish off with about two inches of charcoal at the top of the box and sprinkle a little salt over it. Put the cover on the box, calk with clay, and place in the furnace for ten to fifteen hours, according to the amount and size of the work to be case-hardened. Heat to a bright red and cool in cold clear water.

The size of the box used for the above mixture is about twelve inches deep, fifteen inches wide, and forty inches long. It will hold one set of links, blocks, plates and pins.

Teamwork.—The gift of creating harmony is the keystone of the arch of success without which the structure will not sustain itself. True harmony, when carried to a finality, familiarly known as teamwork, engenders enthusiasm on the part of the individuals forming the organization. An organization without harmony disintegrates and soon becomes utterly demoralized, so that a disturber should be ejected from it with little ceremony, or he will prove its undoing. Departmental lines should vanish before the company's welfare. If, by sustaining an expense, another department can be helped sufficiently to justify the expense assumed, there should be not only no hesitancy, but an eagerness to do so, bearing in mind that the ultimate result to the company as a whole is what should govern. Where possible to do so, however, it will be found that the introduction of a friendly rivalry between officers of the same relative grade will, if properly handled, produce far reaching results, without in any manner affecting harmony, because of the incentive thus given them to use their intelligence and ability to accomplish at least as much, and, if possible, more than their fellows.—*W. J. Harahan, before the New York Railroad Club.*

Gold Leaf for Signal Blades, B. & O. R. R.—For some time past the signal and paint departments of the Baltimore & Ohio R. R. have been experimenting with gold leaf as a covering for signal arms, in an effort to retain distinctness of color without having to resort to painting the arms three or four times a year. The signal engineer of the road is reported as greatly pleased with the results of the experiment, which seem to justify its continuance as standard practice, for the reason that under all varieties of background the arm so prepared presents a more distinct aspect, which consequently is favorable to the runner. While the first cost is comparatively high, the results indicate that the reduction in maintenance will more than offset this and make the gold leaf arms cheaper in the long run.

Locomotives with Schmidt Superheaters.—On December 2, 1908, there were 1,898 locomotives in actual operation and 1,743 in course of construction, fitted with Schmidt superheaters. These are distributed over 101 different railway systems. Among the American railways participating are the Canadian Pacific, 33 locomotives; Great Northern, 2 locomotives; Chicago, Burlington and Quincy, 2 locomotives; Northern Pacific, 1 in operation and 2 on order; Pennsylvania, 1 ordered; making a total of 41 locomotives.

$89^2 = 79 \times 99 + 100$

DATA OF SPECIAL INTEREST TO THE DRAFTING ROOM

PROCESS FOR SQUARING MENTALLY.

(Furnished by W. E. Johnston, Nor. Pac. Ry., St. Paul, Minn. Taken from Robinson's "Higher Arithmetic," page 236.)

Rule:—Add to, and subtract from the number (a) to be squared, a number (b) whose square is known and which will make the sum (a + b) or the difference (a — b) a multiple of ten so as to be a convenient multiplier. Multiply this sum by the difference, $[(a+b)\ (a-b)$, and add the square (b^2) of the number added and subtracted. The result $(a+b)(a-b)+b^2$ equals the square (a^2) of the number as desired.

For $(a+b)(a-b) = a^2 - b^2$

Therefore $(a+b)(a-b) + b^2 = a^2 - b^2 + b^2 = a^2$

Arithmetical example:—

(1) $89^2 = (89 + 11)(89 - 11) + 11^2$
$(100 \times 78) + 121 = 7921$

(2) $56^2 = (56 - 6)(56 + 6) + 6^2$
$(50 \times 62) + 36 = 3136$

(3) $21\tfrac{1}{2}^2 = (21\tfrac{1}{2} - 1\tfrac{1}{2})(21\tfrac{1}{2} + 1\tfrac{1}{2}) + 1\tfrac{1}{2}^2$
$(20 \times 23) + 2\tfrac{1}{4} = 462\tfrac{1}{4}$

(4) $192^2 = (192 + 8)(192 - 8) + 8^2$
$(200 \times 184) + 64 = 36864$

JIB CRANE DESIGN.

(From Theo. F. H. Zealand, Whiting Foundry Equipment Company, Harvey, Ill.)

Frequently motive power officials, when contemplating the purchase of jib crane equipment, prefer to submit designs of their own upon which crane manufacturers are invited to offer quotations; often cranes built from the designs thus submitted would be unsafe in the service for which they are intended, the weak member of the design being the jib C.

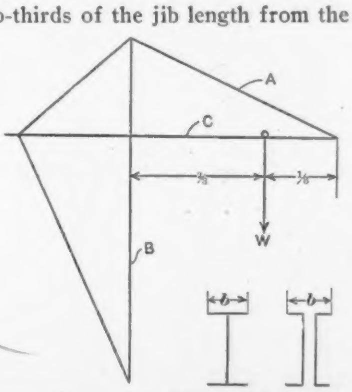
The stresses in this member are imposed as follows:

Bending due to the load W.

Bending due to the weight of the jib.

Compression due to the tension in A.

All these produce compression in the top flange of the beam C, which compression is a maximum when the load is placed approximately two-thirds of the jib length from the mast B. These



calculations are usually made with sufficient accuracy but, when choosing the size of the beam or channel for the jib C, no account is taken of the tendency of the top flange of the beam to deflect laterally due to the compression. To guard against this the allowable compressive stress in this member must be reduced, necessitating the use of a larger size beam than would otherwise be required.

The allowable compression per square inch of cross sectional area is given by the following empirical column formula, where *l* equals the length of the jib from the mast to the extreme end and *b* equals the flange width of the beam, both dimensions expressed in inches; the working compressive stress used throughout the design being 10,000 pounds per square inch:

$$P = \frac{11250}{1 + \frac{l^2}{3000\,b^2}}$$

P is the allowable compression per square inch in the top flange.

No claim is made to originality in connection with the formula given. It is to be found in any good structural steel handbook, as

$$P = \frac{18000}{1 + \frac{l^2}{3000\,b^2}}$$

giving a reduced allowable stress corresponding to a working stress of 16,000 pounds, as used for quiescent loads.

ARCS EQUAL TO STRAIGHT LINES.

(Furnished by W. E. Johnston, Nor. Pac. Ry., St. Paul, Minn. From "Elementary Mechanism" by Stahl and Woods, pages 75-76. Rankine's Methods.)

1.—To find a straight line whose length is equal to a given arc of a circle.

Let AB be the given arc. Draw AC tangent to the arc at A,

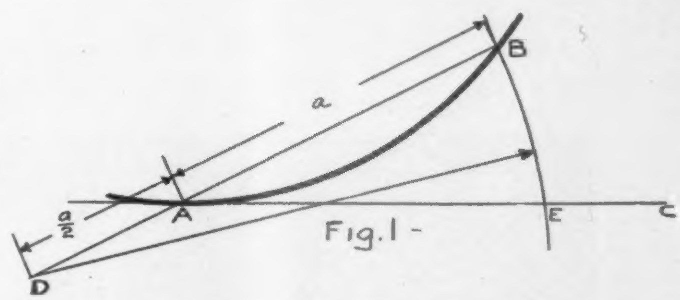


Fig. 1 -

also draw the chord AB and extend it to D, making AD equal to one-half of the chord AB. With D as a center and DB as a radius, draw the arc CE intersecting the given circle AB at the point E. Then the arc AE equals the line AC.

2.—To find an arc of a given circle whose length is equal to a given straight line.

Let AB be the given circle and AC the given line. Lay off AD equal to one-fourth of AC. With D as a center and DC as a

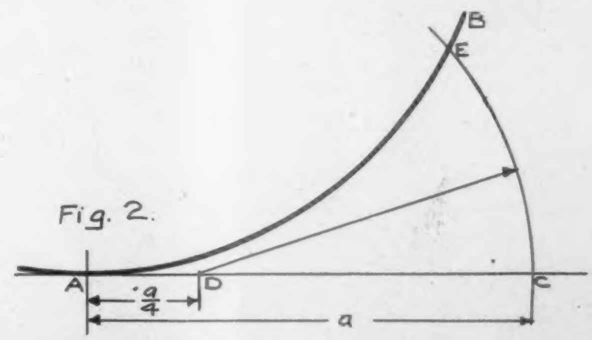
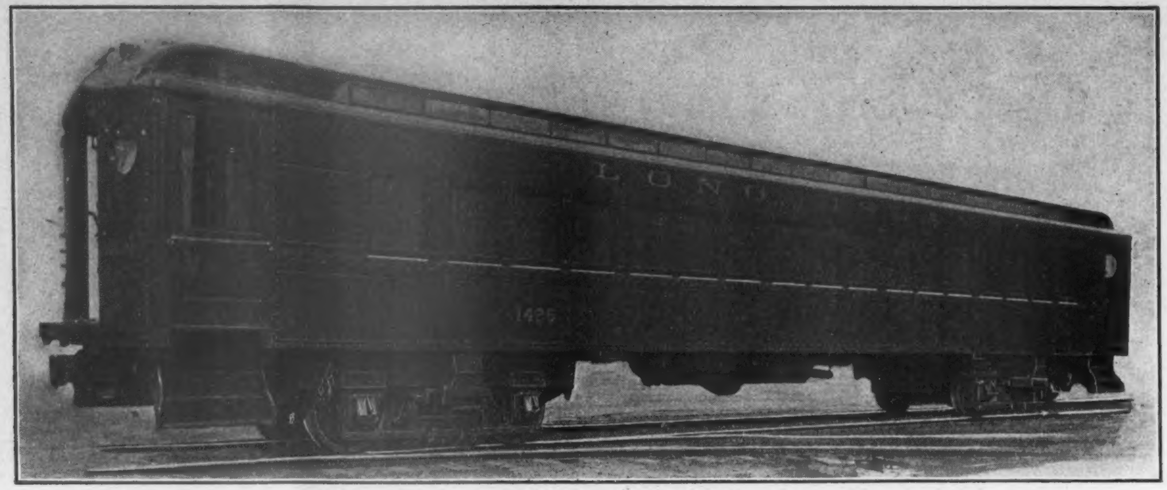


Fig. 2.

radius, draw the arc CE intersecting the given circle AB at the point E. Then the arc AE equals the line AC.

The error in each of the above methods is about 1/900 when the arcs AB and AE in Figs. 1 and 2 respectively are 60°, and varies as the fourth power of the angle so that the error at 30° is about 1/14400, the line being shorter than the arc.



ALL-STEEL SUBURBAN CAR—LONG ISLAND RAILROAD.

ALL-STEEL SUBURBAN CARS.

LONG ISLAND RAILROAD.

The Long Island Railroad is putting into service the order of fifty all-steel suburban cars, which it recently received from the American Car and Foundry Company. These cars represent the latest development in equipment of this class and are excellent in every particular. While they were designed for and can easily be adapted to electric service, they are for the present to be used in steam service and are being operated out of the Long Island City terminal.

As can be seen by the illustrations, they are of the standard design for all-steel passenger equipment adopted about a year and a half ago by the Pennsylvania Railroad, which was described and illustrated in the June and July, 1907, numbers of this journal. Reference can be made to those issues for drawings and photographs of all details. The theory on which the designs were based has been fully treated in the series of articles on "Steel Passenger Equipment," by Messrs. Barba and Singer, which has been running in these columns during the past year. Reference can be made to the December, 1907, and June, 1908, numbers for discussion on the design of underframe for suburban cars of this class.

In brief, the structure consists of two 9-in., 15-lb. channels, with a ¼-in. cover plate on top and ⅜-in. plates on the bottom, forming a box girder center sill. The side sills are 5 x 3½-in. angles and transfer the load of superstructure and one-half the lading to the center sills through four special cantilevers, two of which form the body end sills and the others, of heavier construction, being located at the proper points between the center plates. No bolsters are provided, the center plates, which are of a special extension design to reach the same trucks used on heavier equipment, being secured directly to the bottom of the center sill girder. Cross bearers are provided between the sills for horizontal stiffeners, but do not assist in carrying the

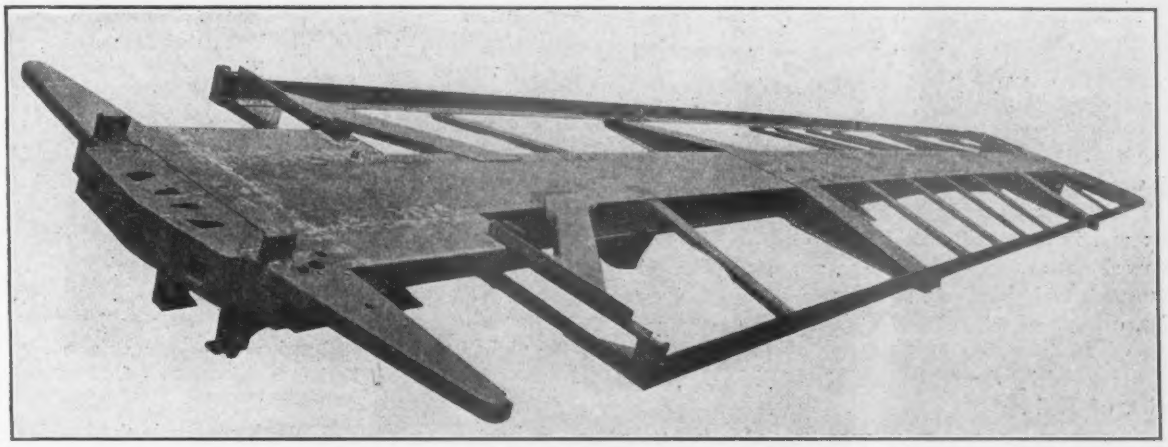
INTERIOR OF ALL-STEEL SUBURBAN CAR—LONG ISLAND RAILROAD.

load coming to the side sills or on the floor. The main side posts are of pressed steel in channel section, with the edges flanged out parallel to the web and riveted to the sheathing. The upper ends are narrowed down and curved inward, forming the lower deck carlines. The upper deck carlines are of the same section. The inside and outside sheathing, roof, etc., is of steel sheets of varying thickness. A combination deck sill and plate of special flanged shape, stiffened by malleable iron posts is an interesting feature of the roof construction. All mouldings for interior finish are pressed steel as are also the guides in the window frames. The window sashes are wood, but the frames are flanged steel in one piece. The floor is formed of plastic cement laid on corrugated steel plates.

The interior finish is unusually attractive, the color being a warm tone of green relieved by a small amount of border stripping. The seats are of the Hale & Kilborn walk-over type with steel frames, wooden arm rests and rattan covering. Hand holds are formed in the outer corner of the backs. A continuous basket rack of substantial design has been provided. All doors are of the sliding type, the vestibule doors being operated by the guard standing on the buffers between the cars. A trap door and step are provided for use where there are no raised platforms.

The trucks are of special design and are arranged for the easy installation of motors. They were fully illustrated and described on page 237 of the June, 1907, issue of this journal. The trucks under these cars differ from those illustrated in having quadruple instead of sextuple elliptical springs under the bolster. They have 36-in. wheels and a 7-ft. wheel base.

The cars have a length of 54 ft. 5¾ in. over the body and 64 ft. 5¾ in. over buffers. They weigh 77,100 lbs., which, of course, is without any electric equipment.



UNDERFRAME OF STEEL SUBURBAN CARS FOR THE LONG ISLAND RAILROAD.

KEEP IN TOUCH WITH PROGRESS.—He who would seek to develop his capabilities to the fullest extent and keep that proper pace with progress, absolutely required for the continuation of success, should read carefully the literature of the profession. It is as necessary for the successful railroad officer to follow the changed conditions surrounding railway practices, and to know the new and advanced ideas and physical improvements as it is for the lawyer or doctor to do so in his profession. The railway and engineering periodicals and certain books on railroad subjects are the most valuable aid to him and should be freely used. They contain everything that is current and information pertaining to all departments so that a man may inform himself fully as to not only the work of his own department, but as to that of other departments.—*W. J. Harahan, before the New York Railroad Club.*

LARGE SAW MILL.—A saw mill at Bogalusa, La., belonging to the Great Southern Lumber Co., has a capacity of 600,000 ft. of sawed lumber boards per day. This is sufficient to build a little town of 40 houses in addition to a good-sized church and a school house.

AN AIR AND STEAM SUPERHEATER FOR LOCOMOTIVES.

The New Century Engine Company, Ltd., London, is introducing an apparatus for the purpose of combining and superheating air and steam for use on a locomotive, which has been devised by Messrs. Field & Morris and is illustrated and described in *The Engineer.* This apparatus consists of two air compressors which are attached ahead of the cylinders and operated by an extension of the piston rod, or can be operated by connection to the cross head, and furnish compressed air at boiler pressure. A relief valve is provided to prevent excess of pressure. This compressed air is fed into a superheater of practically the Pielock design, except that it is located in the front end and adjacent to the front flue sheet, the boiler tubes being extended to pass through it. The steam from the dry pipe enters near the same points as the air and in passing through the baffles of the superheater they are thoroughly mixed and superheated.

This apparatus has been given a very thorough test on the North British Railway and has indicated a very substantial economy in coal consumption. This economy is explained in two different ways, one being that the air forms an envelope around the steam particles and thus resists the tendency to condensation as the temperature and pressure falls during expansion. Another explanation is that the compressed air itself contains considerable heat and since its temperature is higher than the steam at the same pressure it exerts a superheating action to some degree which allows the superheater itself to give a much higher degree than it would give with steam alone.

INSTRUMENT FOR MEASURING COLOR.—The difficulty of maintaining a standard by which colors for car bodies, etc., can be accurately gauged is easily understood and an instrument for performing this service has been invented by Frederick E. Ives and is in use in the Arthur D. Little Laboratory in Boston. This instrument is called a colorimeter, and is arranged to give a scale reading. After the standard shade has been determined, a board is carefully painted in the same manner as the paint will be used in practice and the color measured by the instrument, which thus gives a scale reading. This reading being recorded, the same color can be duplicated at any time by preparing sample boards which will be correct only when the instrument will record the same reading as was originally given as the standard. The same procedure is, of course, possible for determining the exact shades of different components which go to make up the composite color desired.

AIR COMPRESSORS IN ROUNDHOUSES.—The air compressor should have a capacity of about twenty cubic feet of air per minute per engine house pit, delivering the air into a receiver or reservoir at a pressure of one hundred pounds per square inch.—*R. D. Smith before the New England Railroad Club.*

ARTICULATED COMPOUND LOCOMOTIVES

American Society of Mechanical Engineers.

At the annual meeting, held in New York, December 1 to 4, C. J. Mellin, member of the Society and consulting engineer of the American Locomotive Company, presented a paper on the above subject, which was discussed by a number of the best-known locomotive experts. Mr. Mellin stated in part:

"The constantly increasing demand for heavier power, made by most railways in the country during the last decade, and especially by those roads having heavy gradients combined with sharp curves, brought out various designs which on account of rail pressure limitations required so many coupled wheels that the length of the rigid wheel base made them unwieldy to operate with efficiency. This demand for greater power was, of course, greatest in mountain districts where heavy grades and sharp curvatures generally go together, necessitating, for safe operation, comparatively short wheel bases, reduction in engine resistance and wear of wheel flanges and rail, together with moderate weight of the working parts of the engine.

"In striving to meet this demand the locomotive designers and builders were brought face to face with an unsurmountable barrier to further progress in the enlargement of engines on the old lines; and in 1902 the American Locomotive Company decided to work out a design of a heavy, powerful locomotive for the Baltimore & Ohio Railroad, having two sets of engines under one boiler, capable of adjusting themselves independently to the alignment of roads with curvatures up to 30 degrees, on the principle developed by the prominent French engineer, M. Anatole Mallet, of Paris.

"Mr. Loree, then president of the Baltimore & Ohio Railroad, considered the question seriously; but it was first thought that it would be of no advantage to the Baltimore & Ohio Railroad, even if it proved successful, and the subject was left undecided for some time. In the latter part of 1903, on the recommendation of Mr. J. E. Muhlfeld, who in the meantime had become general superintendent of motive power, the Baltimore & Ohio ordered one engine of this type,* which was built at the Schenectady Works of the American Locomotive Company during the winter of 1903 and 1904, to suit the conditions of that railway.

"The Mallet articulated arrangement presents the advantages of enormous tractive power concentrated in the combination of the two sets of engines, with practically no increase in the individual weights of the moving and wearing parts over those of engines of the ordinary types; double expansion of the steam; simplicity and ease in operation and a short rigid wheel base, with the weight distributed over a long total wheel base, resulting in the greatest flexibilty and ease on track and brdges. It was also found possible at the very first to provide an engine under the control and operation of a single crew, having double the power of the largest engines of the ordinary type.

"Opinions on the use of a truck in the articulated engine are, however, divided, but, because of the many objections connected with the application of a front truck in freight service as to the first cost, maintenance, dead weight and unfavorable distribution of the machinery sometimes causing serious obstructions, nothing is gained by this objectionable feature, as it is practically the same as putting a truck ahead of a truck.

"The front engine in going ahead being a truck in itself, the first pair of drivers have a leverage in their favor on entering the curve. The reason for this is that the virtual support of the weight of the rear system, which is carried by the front system, falls back on the latter and in the rear of the sliding bearing; thus allowing a great part of the load of the rear engine to be carried by the hanger bolts between the frames.

"This alone reduces the pressure very materially on the sliding plate, which together with the short arm for friction resistance and long guiding arm for the flanges, reduces the pressure on them to a small fraction of the total friction load on the sliding plate and comparatively light centering springs will therefore suffice for this purpose and still further reduce the flange pressure.

"These same leverages and resistances act equally favorably in backing, as it is simply a reverse operation and the rear drivers have to swing the boiler against these resistances. Therefore, it is important that these should be small and with the shortest possible leverage, which naturally also minimizes the flange pressure on the rear wheel, that is, the last wheel of the engine, which then has to do the guiding.

"With the use of a front truck, the center of support is shifted forward and with it the virtual and actual supporting points of the weight of the rear engine carried on the front system. The weight on this support, must, therefore, be increased with the carrying capacity of the truck and offer little or no opportunity for transferring any of this load to the hanger bolts, practically doubling both the load on the sliding plate and the length of the resistance arm. At the same time, by the application of a front truck, the guiding point is moved forward so that the leverage has been increased to offset the increased side resistance of the engine. The guiding power of the truck, however, is limited to its swing resistance. This, therefore, may leave as much or more guiding to be done by the front drivers as where no truck is used because of the increased moments of resistance of the engine when curving.

"A more serious matter, however, is the backing with a front truck. The high resistance moments in the front must be overcome by the rear drivers, which are doing the guiding, and it is easy to understand how fast the flange pressure is multiplied by this displacement of the load and the safety margin for derailing dangerously reduced. It is, therefore, evident that a rear truck is a necessity when a front truck is used where backing is to be considered, thus curing one evil with another. Even with the application of a rear truck, the objections caused by the application of the front truck will be only partly compensated for; as the following very essential objections still remain:

a. The application of a front truck increases the distance of the front buffers from the first pair of drivers by 15 to 20 per cent., and consequently throws the front drawhead of the engine further from the center of the track in curves than with shorter extensions where no front truck is used.

b. It increases the total wheel base of the engine about 8 ft. 6 in., requiring an 80 ft. turn-table to take an average sized engine with its tender.

c. Additional dead weight to be carried by the truck must be provided and the expenses in maintenance and first cost by the use of it are items that should not be overlooked.

d. The long arms for friction resistance on the sliding plate with increased load on them, due to the front truck, will not be lessened by the application of a rear truck.

e. When only a front truck is applied, the boiler is necessarily moved so far forward that it leaves scant room for the valve motion on the rear engine. The result of this is that the width of the firebox is necessarily limited to about 72 in.

"In the case of the passenger engines of the articulated type, however, large wheels would be used, and only four pairs of drivers can or need be applied. A four wheel front truck, with rigid center pin and rigid trailing wheels, works in conveniently in the place of a third pair of drivers in each engine front and rear, respectively, which otherwise, with their large diameter, would make the engine unduly long.

"Among the various differences between this class of engines and that of the ordinary type, is the action of this engine when

* See American Engineer, June and July, 1904, pages 237 and 262.

loaded to the slipping point. While the former is less liable to slip than the latter, due to a more uniform pressure on the pistons, they will not be considered loaded to anywhere near their capacity until slipping takes place, and consequently slipping does occur on heavy grades. With the ordinary engine, slipping at such times is a serious matter, as the train is losing speed and may stall on that account after a few repetitions. In the case of the articulated engines, the loss in power by the slipping of one engine is practically gained by the other in the increase of unbalanced pressure that thereby results.

"The effect on cars and draft gears in starting heavy trains by this type of engine, as well as convertible compound engines on the same principle, is a most important feature, as it is accomplished with a so-called dead pull, without the necessity of taking advantage of the slack in the train with its destructive jerks. These locomotives are, therefore, easier on the draft gears than simple engines of half their size loaded to their full capacity. The reason for this is found in the great starting and emergency power, with which these engines are provided, so that the slack is taken up under very slow speed. This is generally done with light throttles. The front cars start successively under a slight acceleration of the engine, gradually going over to a retardation before the last cars get into motion, after which the engine is given full throttle. In other words the train is stretched first and then it is started under direct pull, so that there need not be any but slight shocks or jerks.

"These engines are adaptable to a greater variety of conditions than the older types, rendering it possible to double the engine power on a given rail weight; and their advantages are most pronounced as displayed on heavy grades and sharp curvatures.

"It should also be remarked that, due to the absence of jerks and slack in starting, as well as the more uniform cylinder pressure, the stresses on the machinery and framework are considerably reduced; and, further, that the milder exhaust produces a less intense heat and a better utilization of it, all of which contribute to a reduction in the repairs of the locomotive as a whole, compared with a simple engine, if it were practical to construct one of this type. This has never been advanced as a feature to the credit of the articulated engine because it is difficult to give it any definite value; but is referred to as a reply to the often repeated supposition that these engines are hard to keep in repair. As a matter of fact, the opposite is the case, because on account of sub-division of the work in two engines the parts are lighter and easier to handle in repairs and renewals."

The paper also discussed briefly the distribution of weight in an articulated locomotive, which subject will be fully treated in a special article in the next issue of this journal. There was also included illustrations and descriptions of details of various locomotives that have been built, most of which have been illustrated in these columns. A number of proposed designs, for both passenger and freight articulated locomotives, were included, as well as photographs and general dimensions of all of this type of locomotive that has been built in this country.

DISCUSSION.

In opening the discussion F. J. Cole analyzed the features of construction which differentiate the Mallet from other types and enables it to perform satisfactorily and efficiently its remarkable work in Europe and this country. Among these he mentioned the short rigid wheel base, the fact that the flexible steam connection has only to carry low pressure, the practical impossibility of both engines slipping at the same time and the extreme flexibility of the machine. The possibilities of the designing of enormous locomotives with a reasonable axle load was commented upon and tables given. He mentioned the surprising ease with which these engines were fired and attributed it largely to the use of compounding, which reaches its maximum efficiency at slow speeds and long cut-offs. He stated that, "in ordinary service, especially for helping and pushing, the use of leading truck wheels is entirely unnecessary. It is of great advantage to utilize the entire weight for adhesion and no useful purpose is served by adding the additional complication of truck wheels. No sharp flanges have developed on the Baltimore & Ohio locomotive after four years of service, although this locomotive is operated twenty-four hours a day pushing up hill and backing down over sharp curves. In comparison with ordinary consolidations in use on this road, which do wear their flanges badly, this fact is extremely gratifying, and proves conclusively that the extreme flexibility of this engine is sufficient in itself to move freely around curves without the use of guide wheels. * * * * Except for the possible use in road service, where the speeds exceed 40 or 45 miles per hour and the requirements from the boiler are such as to render it impossible to utilize the entire weight for adhesive purposes, the employment of leading or trailing wheels does not seem to be necessary and it seems to me that the principle justification for their use may be found in cases where the extreme boiler capacity is required and that under such conditions only will their use be justified."

Harrington Emerson stated that a few years ago Bion J. Arnold had remarked that there was no known way of moving freight as cheaply as putting a steam locomotive ahead of the train. In connection with the contention of the electrical engineers during the past few years, who had attempted to prove their case by assuming ideal conditions for electric traction and that the current locomotive practice was the best attainable, he remarked that two things had put the electrification far into the future, one was the panic, which reminded railroad managers very forcibly of the financial situation and the other was the Mallet type of locomotive. He related a few instances in connection with the large Santa Fe type of locomotives which, while operating most economically, had so long a wheel base as to cause considerable trouble with the track, and said that the Mallet type would give all, and more, advantages than the Santa Fe and at the same time would correct the trouble with the long wheel base.

L. R. Pomeroy considered briefly the commercial side of the introduction of the Mallet type of locomotive, which in a number of special cases had proven to be the remedy for present conditions that it has previously been believed could only be improved by the substitution of electric traction. He took up a special instance of a 50-mile mountain section, having a maximum grade of 2.2 per cent., with seven trains per day in each direction. The reduction of one-half in train mileage, with the same tonnage, at 50 cents per train mile, this rate covering the items directly affected and used in computing the saving to be advantageous in grade reduction, would save $65,000 per year, which capitalized at 6 per cent. would equal $1,000,000. In order to obtain this saving electrically the complete electric apparatus would cost considerably more than this capitalized amount, whereas the required number of Mallet compound steam locomotives to perform the service would cost about one-third the amount necessary for an equivalent electric service. Stating the case in another way and basing the saving on the reduction in train crew expense, leaving out all other advantages, it is seen that with a total of 14 trains, which is equivalent to about 700 train miles per day, the cost of the train crews amounting to 12½ cents to 15 cents per train mile, the saving then, in reducing the train mileage one-half, would equal $17,800 per annum, which at 6 per cent. is a capitalization of about $300,000, or more than enough to pay for the required number of Mallet locomotives to perform the service.

This is not meant to be a reflection upon the possibilities of electric traction in general, but was simply a particular case, which was not at all unusual, where the magnitude of the business would not justify an electric proposition, but where the Mallet locomotive could obtain all of the savings that electric traction would obtain on a larger basis, and would serve as a very profitable bridge between the present conditions and the eventual traffic density where electric service would be advisable.

George L. Fowler, on request of Dr. Goss, drew attention to the credit that is due Mr. Mellin for developing Mallet's engine, which was originally designed for narrow-gauge lines and was of light weight, into the enormous and powerful machines that are now being built on this principle.

G. R. Henderson briefly drew attention to the fact that in order to obtain the full advantage of these large locomotives it would

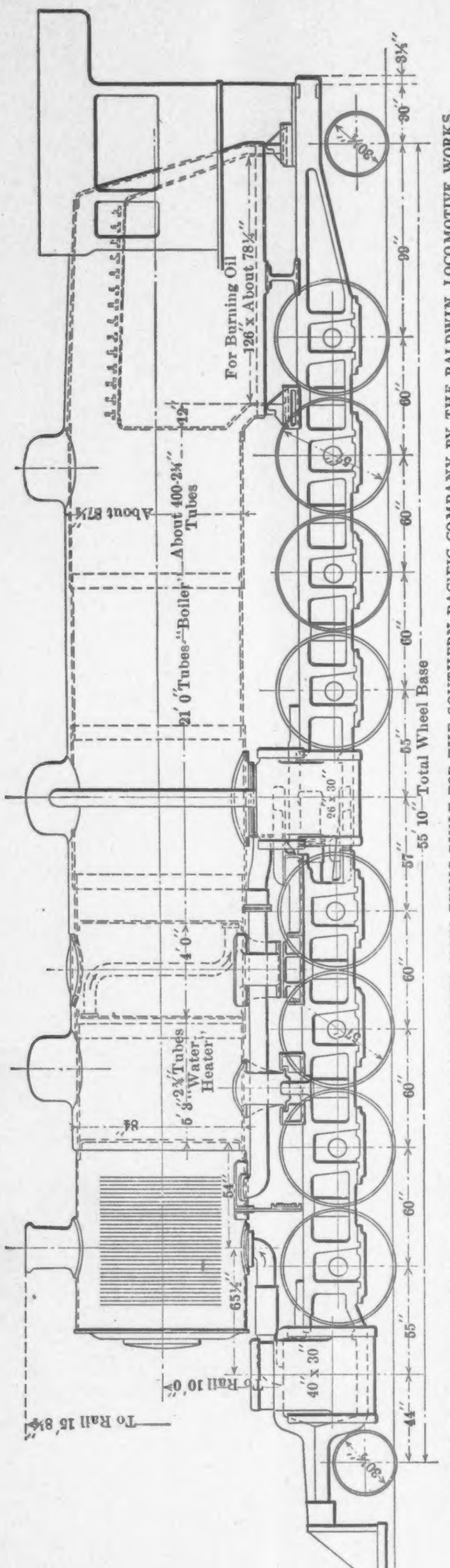
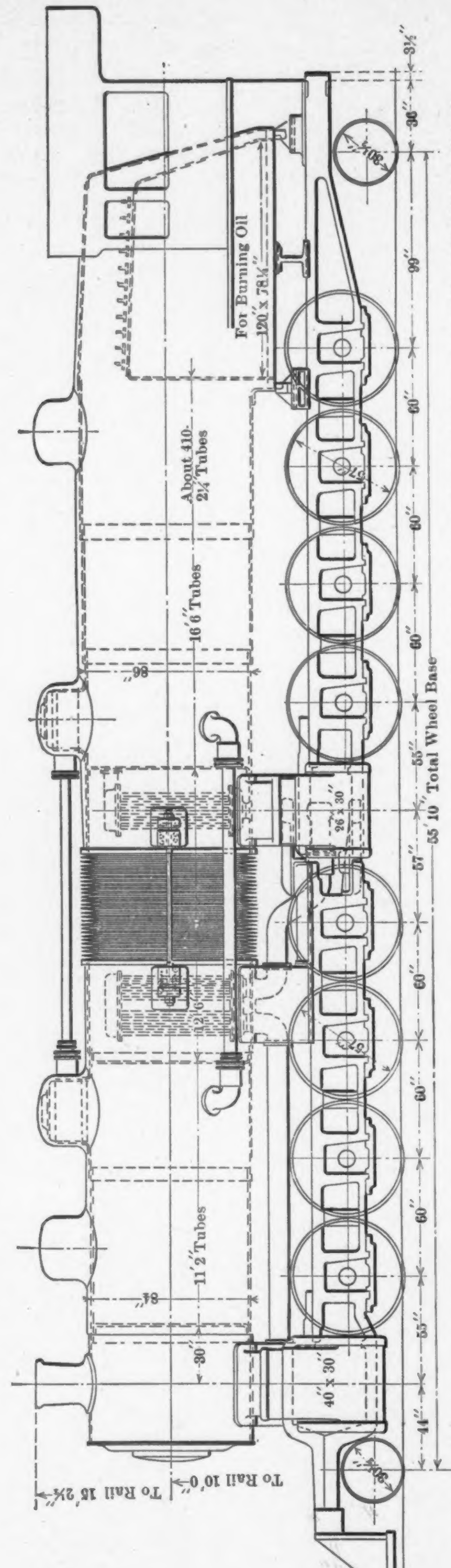
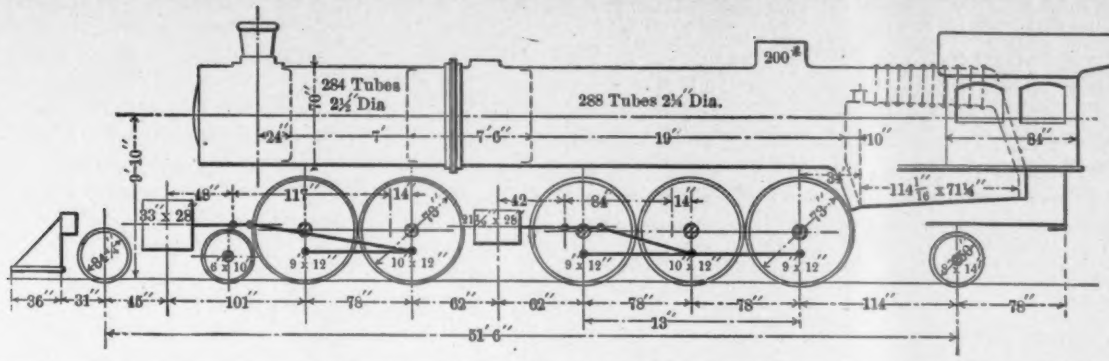


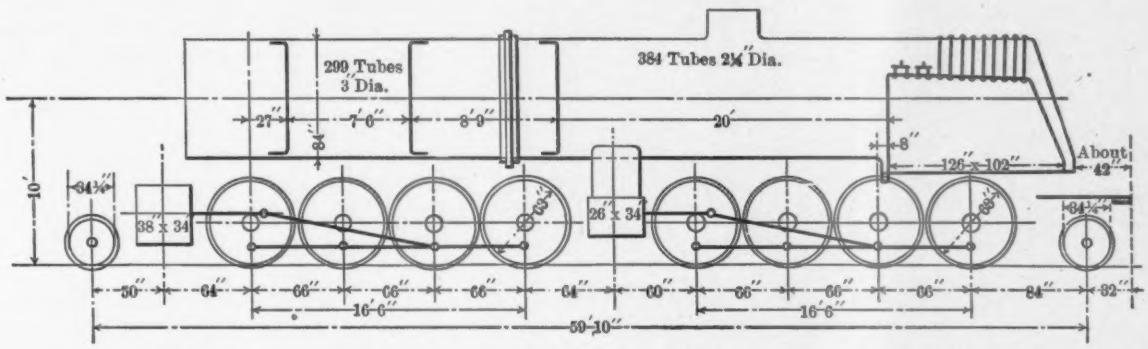
DIAGRAM OF ARTICULATED COMPOUND FREIGHT LOCOMOTIVES NOW BEING BUILT FOR THE SOUTHERN PACIFIC COMPANY BY THE BALDWIN LOCOMOTIVE WORKS.



DESIGN FOR ARTICULATED FREIGHT LOCOMOTIVE WITH FLEXIBLE BOILER, PROPOSED AND DESIGNED BY S. M. VAUCLAIN OF THE BALDWIN LOCOMOTIVE WORKS.



ARTICULATED COMPOUND PASSENGER LOCOMOTIVE FOR THE SANTA FE, UNDER CONSTRUCTION AT THE BALDWIN LOCOMOTIVE WORKS.



ARTICULATED COMPOUND FREIGHT LOCOMOTIVE FOR THE SANTA FE, UNDER CONSTRUCTION AT THE BALDWIN LOCOMOTIVE WORKS.

be necessary to give careful attention to the development of automatic stokers.

S. M. Vauclain, general manager of the Baldwin Locomotive Works, discussed the subject at some length by means of a large number of lantern slides. He showed a photograph of Monsieur Mallet and spoke most highly of his great ability as a designer and expressed regret that owing to the expiration of patents, etc., he would not receive the pecuniary returns which by right should be his. Mr. Vauclain briefly followed the early history of this type of locomotive, showing drawings of the DeCauville Railway locomotive, which he believed to be the first one of the type ever publicly exhibited. He stated that it was in 1877 that Mallet first designed an articulated compound locomotive.

Lantern slides were then shown of a design which was submitted in 1898, by the Baldwin Locomotive Works, to the Erie, but was not accepted. Following this a large number of slides were shown of outline diagrams of studies which had been made for locomotives of this type for use on the Santa Fe. These studies included a great variety of arrangements of cylinders, combustion chambers, re-heaters, feed water heaters, etc., and all of them, except the first, included a leading pony truck and most of them also had a trailing truck. This series of studies was completed by the design of freight and passenger locomotives which are shown in the above illustrations and are now under construction at the Baldwin Locomotive Works. It will be seen that in both of these the boiler proper, with the ordinary firebox and 19 and 20 ft. tubes, ends in a large combustion chamber, ahead of which the shell is continued and tube plates, with a nest of large tubes, are arranged to form a feed water heater, ahead of which is the front end with the exhaust pipe and stack. In the combustion chamber is to be located a superheater, or a re-heater, or possibly both, and the boiler shell is arranged to be easily disconnected at this point for inspection and cleaning of the apparatus. The freight locomotive is of the 2-8-8-2 type and has 63 in. drivers with a 34 in. stroke, the cylinders being 26 and 38 in. in diameter. The passenger locomotive is of the 4-4-6-2 type, with 73 in. drivers.

Following this series of studies, examples were shown, by means of drawing and photographs, of other articulated compound locomotives built by the Baldwin Locomotive Works during the past few years, all of which have been illustrated in these columns.

Mr. Vauclain then showed a series of diagrams illustrating the development of a design of articulated compound locomotive for the Southern Pacific. This started out with a desire to apply the principle to a tank locomotive which would carry its coal and water on the locomotive frames. This however, was finally given up as impractical and after several different steps the design shown on the opposite page was accepted and two of this arrangement are now being built at the Baldwin Works. It will be seen that this is somewhat similar to the Santa Fe freight locomotive, the wheel arrangement being the same, but that the reheater is located in the front end proper, the combustion space being considerably shorter, as is also the feed water heater. In this case the boiler is not arranged to be disconnected at the combustion chamber, but a manhole is fitted for admission to this space from the top. These locomotives have 57 in. drivers and a 30 in. stroke, the cylinders being 26 and 40 in. in diameter.

Mr. Vauclain then threw a design on the screen, which he presented as a proposed arrangement of what he guaranteed would be an entirely satisfactory design for a heavy freight locomotive. This design is also shown on the opposite page. In it there is introduced an entirely new and novel feature and idea; that is, of having a flexible boiler as well as an articulated frame, so that there would be no necessity for the front group of frames to move relative to the boiler in taking curves. Mr. Vauclain is willing to back up this design to the fullest extent. The illustration shows the general features very clearly and it will be seen that it includes both a superheater and a reheater, located in a large combustion chamber, at which point the bellows connection is also placed, and it has the low pressure cylinders attached to the front end in the ordinary manner.

The remarks of the speaker were closed by showing some foreign locomotives of small size which had been equipped with front and trailing trucks.

Mr. Vauclain also briefly referred to a discussion on the paper that had been furnished by Mr. Emerson of the Great Northern Railway, which will be printed in full in the proceedings of the society. Mr. Emerson confined himself to a report of the service that the locomotives on his road, which now number about 68 of two sizes, had given during the past two years. This experience was so favorable that it has been decided to extend the use of this type of locomotive to districts having grades as low as .72 per cent.

On the Cascade division of that road, where the ruling grades vary from 1 per cent to 2.2 per cent the service had previously

been performed by consolidation locomotives having 20 x 32 in. cylinders, 55 in. drivers, 210 lbs. of steam and weighing 180,000 lbs. on drivers.

"In the beginning the large Mallets were first introduced on the hill between Skykomisk and Leavenworth on the Cascade division with a consolidation engine used as road engines and the L1* helpers used on the hill only. Up to the present time the tonnage over these mountains has been gradually increased from 1050, with two consolidations, to 1600 tons now being hauled with the L1 engines. The L1 engines have now entirely replaced the consolidation engines and it is the practice to start out from Everett with one L1 engine used as a road engine, taking 1600 tons as far as Skykomisk, over a ruling grade of 1 per cent. At Skykomisk another L1 engine is put on as a pusher and takes the 1600 ton train over the mountain. The tonnage hauled in the opposite direction is the same and the L1 Mallet has proven itself to be not only valuable for helper service but a good reliable road engine and the combination of road and helper service works out admirably on this division, making it unnecessary, going east, to reduce the tonnage at Skykomisk in order to get over the heavy grade. Recent performances show that on a round trip over this division the L1 engines hauled 1600 tons with a total consumption of 43.8 tons of coal, equivalent to 25.13 lbs. of coal per 100 ton miles. The consolidation engines could only handle 1050 tons, with practically the same amount of coal consumed, equivalent to 38.29 lbs. of coal per 100 ton miles. In other words the tonnage on this division has been increased at least 52 per cent with the result due to the Mallet engine of a saving of 34.39 per cent lbs. of coal per 100 ton miles.

"Since putting the L1 engines in road service the performance has been so satisfactory that there are now but four of them used exclusively as pushers, two as helpers over the Cascade mountains and two on the Butte division in transfer service.

"On the Spokane division the 1600 tons delivered at Leavenworth is reduced to 1450 tons and a small Mallet, class L2,† takes this train to Hillyard, a distance of 195 miles. These engines have enabled us to increase the tonnage from 1100 tons hauled by the consolidation to 1450 tons, an increase of 31.8 per cent. The run is so long that this tonnage has been established in order to get the trains over the district in a reasonable time and they handle the tonnage at from eight to ten miles per hour on the heaviest hills and up to 30 miles per hour where the grades are not so heavy. The engines are run straight through but crews are changed half-way at Wilson Creek.

"The performance for the year ending June 30, 1908, shows 22.04 lbs. of coal per 100 ton miles on this district, a saving of 27.5 per cent. over the consolidation.

"On the next division east the L2 engine takes a train of 1700 tons from Whitefish to Essex, where the ruling grade is .8 per cent. At this point an L1 helper is put on to assist the train to Summit, a distance of 18 miles, where the ruling grade is 1.8 per cent. West bound an L2 engine takes a train of 1450 tons through, the ruling grade being 1 per cent. On this district the tonnage has been increased 20 per cent, with a reduction of coal per 100 ton miles of 20 per cent. In the next district, from Cut Bank to Havre, a distance of 125 miles, with a ruling grade of .8 per cent, an L2 engine takes 1700 tons over the division. West the ruling grade is 1 per cent and this engine handles 1450 tons. The round trip on this division, with the L2 engine, is made with 32 tons of coal, or an equivalent of 15.75 lbs. of coal per 100 ton miles. The consolidation previously used handled but 1200 tons west and 1425 tons east and used 18.9 lbs. of coal per 100 ton miles, showing an increase of 20 per cent in tonnage and a decrease of 16.6 per cent. in coal per 100 ton miles.

"At another point, where the ruling grade is 2.2 per cent, the L2 engines have increased the tonnage previously handled by the consolidations from 550 to 700 tons.

"The question of maintenance we would naturally expect to be higher on the Mallet engines and for the year ending June 30, 1908, the cost of repairs on the L2 class was 10.47 cents, which is not considered at all excessive. The cost of maintaining the consolidation engines in the same service has seldom been less than 8 cents per mile.

"Another feature which has been noticed is that the Mallet engines are not at all hard on draw bars, owing to the fact that the train is not jerked by the engine slipping and catching, since both engines do not slip at the same time. The tire wear on these engines is very light and the flange wear is not excessive. In fact the Mallet engines have been put on some divisions where the flange wear on the consolidations was very bad and no wear has been noticed on them.

"We still have in service two of the first L1 Mallet engines which have never yet been in the shop for general overhauling. in fact have never been off their wheels and have been in continual service since October, 1906."

* Large type Mallets. See American Engineer, Oct., 1906, page 371.
† Small type Mallet. See American Engineer, June, 1907, page 218.

Copper Safe-Ends for Flues.—Extensive experiments have been made attempting to use copper flues and iron flues with copper safe-ends; brass flues have also been tried, but it appears that the most serious problem is to prevent the rapid destruction of the beads on account of the abrasive action of the fire-box gases and cinder. This was very well proven in a recent experiment on the Norfolk & Western Railway by putting copper safe-ends in a consolidation freight engine equipped with the reinforced flue sheet (see American Engineer, June, 1908, page 207). The engine ran but a short time before the flues began to leak, which condition became continuous, the engine seldom going through a terminal without requiring attention. The heads were finally entirely burned off, and the ends of the flues were reduced to practically a knife-edge. The engine was finally withdrawn from service on this account, the flues having made but 9,189 miles, which is about one-fourth of the mileage we should expect to get with iron or steel.—*Alexander Kearney, assistant superintendent motive power, Norfolk & Western Ry., before the Richmond Railroad Club.*

Timber Waste in U. S.—We are now cutting timber from the forests of the United States at the rate of 500 feet board measure a year for every man, woman and child. In Europe they use only 60 board feet. At this rate, in less than thirty years all our remaining virgin timber will be cut. Meantime, the forests which have been cut over are generally in a bad way for want of care; they will produce only inferior second growth. We are clearly over the verge of a timber famine. This is not due to necessity, for the forests are one of the renewable resources. Rightly used, they go on producing crop after crop indefinitely. The countries of Europe know this, and Japan knows it; and their forests are becoming with time not less, but more, productive. We probably still possess sufficient forest land to grow wood enough at home to supply our own needs. If we are not blind, or wilfully wasteful, we may yet preserve our forest independence and, with it, the fourth of our great industries.—*Treadwell Cleveland, Jr., U. S. Forest Service.*

Honesty.—What may be designated as the first element, or rather, essential, of success, is common honesty. To state the old maxim: "Honesty is the best policy," is but to reiterate a truism, and to repeat parrot-like the principle that has stood the test of ages. There is, however, a broader honesty than that apparent on the surface, that is a requirement. This consists not entirely in the application of the Commandment, "Thou shalt not steal," but seeks also for its guiding principle the "Golden Rule." In other words, a studious and persistent effort to render just and fair treatment to all alike whether he or it be great or small.—*W. J. Harahan, before the New York Railroad Club.*

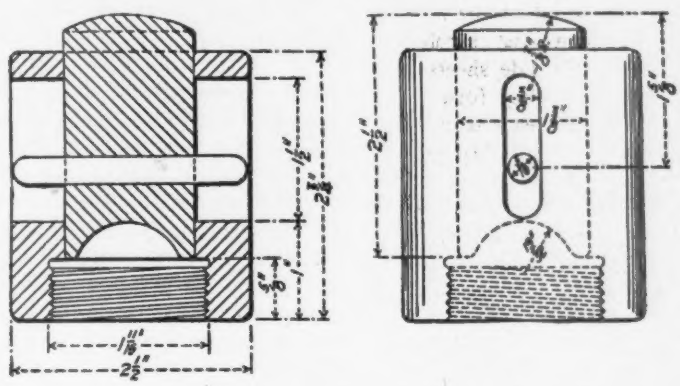
At Altoona, Pa., telephones have been installed in the homes of 517 trainmen of the Pennsylvania Railroad, and all of the trainmen and yardmen of the Middle division are now called to service by telephone, instead of by messenger as formerly. Fifteen callers have been appointed to other positions.

APPLYING FLEXIBLE STAYBOLTS.*

By R. V. ANDERSON.

One of the most important jobs on a locomotive boiler is the proper application of flexible staybolts. Every part of the work has to be carefully performed to be successful. The method used at the Rogers Locomotive Works, which has been very successful, is as follows:

The holes in the sheet are punched 1/32 inch smaller than the diameter, of the root of the thread at the point of the sleeve, and reamed with a taper reamer that has a guide on the point which goes through the firebox sheet. There is a collar fastened on the reamer at the proper place near the head which stops the reamer from going in too far, and allows 3/32 inch for thread, and makes all the holes exactly the same size. The tap has also a guide and a stop on it so the holes are tapped the same. We only use one reamer and one tap in the holes and get a perfect



DEVICE FOR HOLDING ON IN RIVETING FLEXIBLE STAYBOLTS.

thread. The sleeves are screwed in with a stud nut, driven with a ratchet lever. The bolts are run in with an air drill until they are nearly home, then adjusted carefully by hand, taking care to get an equal load on all the bolts without pulling the firebox sheet out of line.

While riveting the bolt we have a simple device for holding on which may be new to some of you. It obviates all danger of spoiling the thread on the sleeve. It consists of a nipple which is screwed on to the sleeve, and has a sliding plunger inside which fits on the head of the bolt. The holding on is done by a common holding on sledge which backs up on the outside end of the plunger. An order of 60 boilers for the Wabash Railroad recently completed had 298 flexible staybolts in each, making a total of 17,880 bolts. The inspector would not permit any calking on the sleeves, but only 10 of them had to be renewed because of leaks. The most important thing needed in putting in flexible saybolts is good judgment. You can have your holes perfect, your reamer perfect, your tap perfect, your bolts and sleeves perfect, yet an injudicious or careless workman will spoil the whole job.

* A paper presented before the Master Blacksmiths' Association.

ANALYSIS OF COST OF LOCOMOTIVE REPAIR SHOPS

George A. Damon, of the Arnold Engineering Company, presented the following analysis of the cost of locomotive repair shops in a paper on "Arrangement of Railroad Shops," read before the Canadian Railway Club:

Our records show that locomotive repair shops which are laid out on a basis of the number of pits required equal to 6 per cent. of the number of locomotives served can be built and equipped complete for an expenditure ranging between $50,000 and $65,000 per pit. If one pit will serve sixteen and two-thirds engines per year, the cost of repair facilities will fall some place between the limits of from $3,000 to $4,000 per locomotive. An investment amounting to the lower limit is absolutely necessary if the engines are to be kept on the road. Just how much more than the lower limit should be spent in order to secure the minimum cost of locomotive maintenance, including all the items of not only actual repair expenses, labor, and material, but also interest, depreciation, insurance and taxes upon the plant provided, is a question that should have the most careful consideration.

The following analysis of the total cost will serve to indicate the relative importance of the decisions that must be reached in order to give each dollar expended a maximum earning capacity.

TABLE OF COST LIMITS FOR LOCOMOTIVE REPAIR SHOPS ON THE BASIS OF TWENTY-FIVE ERECTING PITS.

DIVISIONS	Limits of Cost —Per Pit— "Low."	"High."	Approx. Proportion of Tot. Cost
SHOP YARDS			
Tracks, Crane Runways, Transfer or Turn Tables	$ 1,400	$ 3,000	4%
Water and Sewer Systems	1,000	1,800	2%
Piping and Wiring Tunnels and Tunnel Piping	500	1,000	1%
BUILDINGS.			
Machine and Erecting Shop	8,000	12,000	17%
Boiler and Tank Shop	3,000	5,000	7%
Forge Shop	1,500	2,400	4%
Storehouse and Offices	1,000	2,500	3%
Locomotive Carpenter Shop	500	1,000	1%
Power House	1,200	2,400	3%
Oil House and Equipment	400	600	1%
Miscellaneous buildings: Scrap Bins, Material Sheds, Fences	500	1,000	1%
GENERAL EQUIPMENT FOR ALL DEPARTMENTS.			
Power House Equipment	5,000	8,000	11%
Traveling Cranes	1,500	3,000	4%
Tool Equipment	10,000	15,000	22%
Heating System	1,200	2,500	3%
Power and Lighting Systems, including yard, wiring, and lighting	1,500	4,500	5%
Plumbing and Lockers	300	1,000	1%
Air, Water, Steam, and Oil Piping in Buildings	600	1,200	2%
Incidentals, Organization, and Engineering	2,000	7,000	8%
			100%

NOTE.—These figures do not include items for Real Estate and Preparation of the Shop Site, which cost necessarily varies between wide limits.
The Foundry building and equipment are not included in these figures.

The sum total of the "low" and of the "high" figures shown will result in grand totals which will show a wider range than the 33⅓ per cent. variation indicated by unit figures of $3,000 to $4,000 per locomotive, but as it is improbable that any shop would be built using either the lowest or the highest estimate for every one of its parts it will be found that only in exceptional cases will the actual total cost fall outside of the limits first given.

HARDENING OF STEAM HOSE.—In the case of steam hose the hardening is caused from the fact that there is too much sulphur in the rubber and vulcanization goes on with the heat from the steam, after you commence to use it. If we could get an exact proportion of sulphur this vulcanization would not go on, but this is a very difficult thing to do. The crude rubber is gathered by natives all the world over, and is taken from trees varying from seven years to ten years old, and if you bought ten tons of rubber, you might have ten different qualities.—*A. D. Thornton, general technical superintendent, Canadian Rubber Company, before the Canadian Railway Club.*

ROLLER BEARINGS.—There is almost no limitation for the use of anti-friction bearings, but the possibilities can be better appreciated when it is known that such bearings are sold at prices ranging from 2 cents to $7,500 for a single bearing, and are used to carry loads from a few ounces, running at 30,000 revolutions per minute, to loads of 1,500,000 pounds at 100 revolutions per minute and 250,000 pounds at 500 revolutions per minute.

SIDE SHEETS OF WIDE FIREBOXES.*

C. A. SELEY.

The author prefaced his paper with the following remarks:

"I suppose I ought to make an apology for offering a paper to this club on a matter of pure speculation. I have no data to offer; I built up a theory on a set of conditions which I believe represent the result that we are getting in the life of the side sheets of the modern locomotive. The matter is not new, as it was discussed in the Master Mechanics' Association in 1905, the subject in part being covered by the topical discussion by Lawford H. Fry, of the Baldwin Locomotive Works. There is one paragraph of his paper which I would like to read, part of which I agree with for reasons other than are assigned. He says 'As the water in contact with the side sheets is turned into steam, it must be allowed to rise to the steam space and must be replaced by other waters. The water spaces should be so designed that this natural circulation is aided and that the currents of steam and water impede each other as little as possible. This is secured if the firebox sheets are vertical or with a slight slope outward as they rise from the mud ring, so that the steam can rise along the firebox sheets and the water descend along the outside sheets without mutual interference.'"

* * * * * * *

The life of side sheets in the modern wide-firebox locomotives is a problem that is demanding the active attention of motive power officials because of their decidedly shorter life as compared with side sheets in the older narrow-firebox types. A prominent railway mechanical officer recently stated the matter about as follows: "That the old-style deep firebox with ogee† sides was rather hard on staybolts, but the boxes lasted on an average of from six to nine years. The later wide fireboxes, while easier on staybolts, frequently fail in two or three years." On this showing it was thought that the tendency in firebox design would be towards a modified ogee side with very flowing lines.

The above statement presents an effect and a possible remedy, but does not consider the causes. It is unfortunate if we cannot utilize an increase in the width of the grates to secure the area necessary in large locomotives without having such a decided reduction in the life of the side sheets. It has not been noted that the crown sheets are similarly affected, there has been no radical change in the quality of the steel employed, or of the fuel or service demanded of the locomotive, that would account for the trouble, and we are forced to the conclusion that there must be some element in the design or operation of wide fireboxes which has an unfavorable influence not clearly understood.

By the life of side sheets is meant serviceable condition, freedom from cracks, leakage, and other failures that may require renewal. The life is not particularly affected by the pressure carried, as the staying is generally done with a large factor of safety, but is directly affected by the temperature changes, the expansions and contractions, in service under steam as well as when out of service on sidings or over cinder pits and in washing out, and water changing in the roundhouse.

Steel will stand a certain number of stresses before failure, dependent on the degree or amplitude. We can increase the number of applications of a test specimen by decreasing the amplitude. In a firebox it is difficult to decrease the number of the applications as they are dependent on the service of the engine, the number of times it is fired up and cooled off and these conditions are not materially different for the two types of fireboxes under discussion, and thus it may be that the short life of the side sheets of wide fireboxes can be accounted for by the greater amplitude of the movement or increased expansion and contraction.

At first thought one would say that the ogee box presents a series of curves that will adjust themselves to meet those movements in a way not possible in the straight and more rigid side of the wide box. This is true only in part, as the side is straight longitudinally in both designs, and this is the most important direction. Apparently, therefore, the increased amplitude must be accounted for by a higher internal temperature of the side sheets by reason of less perfect heat transmission to the water in the leg.

In the later designs of boilers we find a general tendency towards the use of wider mudrings and water legs than formerly. This has resulted in giving staybolts longer life, as their increased length gives a smaller amplitude of vibration or motion, but it has also decreased the rate of the flow of the water upward proportionally as the volume of water in the leg is increased. This point will be considered later.

In getting away from the ogee form of box and the narrow water leg, it was thought that the circulation of the water would be improved, as the ogee presents a curve adverse to the direct vertical rise of the water as it is heated and displaced by the cooler water coming from the throat. The results, however, would seem to prove this theory wrong, or at least we have only gained in life of staybolts.

The secret of the matter seems to be that, if the rate of flow and its wiping, scrubbing, impinging action can be directed against the side sheets it has the effect of wiping off the steam bubbles as they form, prevents their combining into a film or curtain of steam against the sheet, which is by no means as good a conductor of heat as is the solid water. This theory will account for increased internal temperature of vertical and inwardly inclined side sheets and can be inferentially proven.

It is well known that crown sheets outlast several sets of side sheets, and while this is due in part to the fact that there are not the same variations of temperature at the same time in different parts of the sheet, it is also true that its surface presents no chance for formation of a film of steam and it has practically solid water in contact with it at all times.

This is also true of the Wooten type of furnace, the parts failing being generally a limited portion at the sides, which approach the vertical. It has also been noted that the door sheets of fireboxes which have moderately inclined back heads do not last as long as those that are vertical. The incline forces the wiping action of the circulation against the outer sheet.

It has been stated that in the early days of torpedo boat design a locomotive type of boiler was tried because of its great efficiency and amount of steam produced per foot of heating surface in locomotive service. On the boat, however, it was an utter failure. By way of experiment this boiler was put on a vibrating cradle, which greatly increased the steam production. This could only be accounted for by an increased circulation, facilitating the heat transmission. It has been proven by late Government experiments that increased boiler efficiency can be obtained by increasing the rate of flow of the gases, this action tending to wipe off from the heating surface the partially cooled gases, replacing them with new and hotter gases.

Thus the questions of circulation, whether of water or gases, seems to be a very important factor in boiler efficiency, and while some of the examples quoted may be somewhat remote in their application, yet they seem to point to the circulation in the water leg as being a vital factor in the life of side sheets.

There seems to be no question that if there is a strong impinging circulation against the fire sheet, the heat will be more freely transmitted, steam film prevented, solid water maintained against the sheet, and the internal temperature of the sheet kept down and the amplitude of the sheet movement reduced to the minimum. To effect this the side sheets should not be vertical nor sloped inward, but be sloped or curved outward from above the fire line, but it is obvious that this cannot be extreme without getting into grate area difficulty.

It is quite possible, however, that we have gone too far and are too liberal in that respect, as the reports of successful steaming of some recent engines would seem to indicate, these engines having a much lower proportion of grate area than is at present common. If a reduction of grate area can be made, it will permit the modification of side sheets as proposed.

The question might also be raised as to the width of water leg. Aside from affording sufficient room to hold the accumu-

* Read at the December meeting of the Western Railway Club.

† The form having a reverse curve in section with the convex part above.

lated sediment to a safe height, there seems to be no good reason for a wide leg except from the staybolt point of view. There is no question of a stronger circulation with the narrow leg, and if need be, some form of flexible staybolt could be considered for extreme cases of angular movement.

In the older designs of fireboxes it was often 80 inches from the mudring to the water level above the crown sheet, the water varying in temperature, while in circulation from 150 or 180 degrees at the bottom to the temperature due to the steam pressure at the top. The depth of this column of water in wide firebox designs is very materially decreased, and as the temperature limits are about the same, it is apparent that for an equal width of water space the rate of flow of the circulation as a whole would be decreased about proportionately to the travel. If in addition to this, the width of the water leg be increased, the rate of movement is further decreased.

If rapid circulation and a wiping effect will serve to carry off the steam bubbles, preventing steam film and overheating of fire sheets, this function has been absolutely sacrificed in many wide firebox designs and the short-lived side sheets seem to prove it. The highest duty boilers are those having the most rapid circulation. The water spaces in legs and between tubes of fire engine boilers are very small, but the probabilities are that the rate of steaming and efficiency would be decreased if these spaces were materially increased and the larger volume of water would lower the rate of circulation.

It is quite likely that the rate of movement in the locomotive water leg has much to do with this question. The water next to the fire sheet has an upward tendency. That next to the outside sheet can only rise when heated by conduction through a body of water equal to the entire width of the leg or by the mingling, mixing action set up when the sheets are not vertical. There seems to be a reasonable ground for the belief that there is a very sluggish circulation in a directly vertical water leg of considerable width, contributing to formation of a steam film and overheating of the sheets when fires are forced.

This discussion would not be complete without considering the other end of the temperature scale to which the fire sheets are subjected. As before stated, it is the amplitude of the vibrations or movement of the sheet which are most subject to control. All possible mileage should be made between knocking out of fires. Firing methods can often be improved so that an engine can be returned without knocking the fire. The usual ash pit methods use up much of the life of side sheets and cold water washing and filling, and rapid firing up takes a lot more. It is quite true that the old-time fireboxes had to stand all this, but while considering temperatures and their effects it would be just as well to help on the lower end of the scale if possible.

Improved methods of blowing down and filling up of the boiler at terminals, hot water changing and washout plants are now well demonstrated and these will all help to reduce the amplitude of the temperature scale traversed in locomotive operation as regards the firebox sheets and thus add to their life.

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After considerable discussion the writer's closing remarks were as follows: "I think I have attained my object in getting a discussion on this rather interesting question. The idea that I had in mind was simply to find some reason why the modern wide fireboxes are lasting one-third of the life of the old-time boxes. In seeking for a theory it occurred to me to consider those elements which contribute to ultimate failure, viz: the vibrations or the expansions and contractions or movements of the sheet in the performance of its duty. I do not know that I am right yet, but at the same time, if there is successful performance of fireboxes about sixty inches wide, and boxes wider than that have not given as good performance, it would indicate that the slope of the sheet due to the narrower width had something to do with it. Now, just how that works out; whether I am correct in supposing that that upward circulation against an outwardly inclined sheet assists in wiping off the steam bubbles and combining them with the current, transmitting the heat, warming up the entire body of water in the water leg, instead of permitting a curtain or film of steam which will contribute to over-heating of the sheet, it at least seems to be a reasonable theory or explanation with some foundation for it.

"Whether Mr. Fry's theory of downward circulation or mine of facilitating wiping action of the circulation are used, the result is the same as regards the desirability of outward instead of inward inclination of firebox side sheets.

"As regards Mr. Squire's inquiry about the solid water, it would seem to me that there is absolutely no possibility of a steam bubble combining with another and another and another until there is a film on any portion of the crown sheet which is considerably beyond the vertical. If the volume of the water leg is increased by greater width of water leg, I think it is reasonably sure that the rate of the circulation as a whole is decreased, due to that larger volume, and if the rate of circulation is a factor in keeping down the internal temperature of the sheet, the failures are in accord with my theory.

"What I am trying to find out is this,—you will probably all admit that a firebox sheet has a certain life, it will stand so many vibrations, so many expansions, so many contractions, from the normal and then it will develop that crack that goes off like a pistol shot, or some other way, at any rate there is a failure of the sheet. Now, that being the case, if we can lengthen out the period of time over which that total movement will happen, we get the increased life in our sheet. It seems to me that if the box is designed in such a way that the internal temperature of the sheet is kept down by keeping solid water against it by any means whatsoever, then with all of the fireboxes, even with the despised ogee, we have made a distinct gain. I think this is a matter worth thinking about and possibly of going into our records of firebox failures. Classify the fireboxes of different widths and angles and forms on our roads and go back through our records for years and find out the number of fireboxes and side sheets that have been applied and see what results we obtain. I do not believe that it is due to the quality of firebox steel falling down necessarily, but probably a matter of design.

"As regards Mr. Wickhorst's belief that there is no downward circulation, or at least that there does not seem to be much to support that theory, I agree with that in a great measure. My idea of the circulation is that it is a very rapid, upward, against the inside sheet and less rapid at the outside, so that a number of inclined lines, each of a greater angle, would express the velocity as I understand it. But I can hardly understand why water up at two-thirds of the height of the firebox against the outside sheet should come down. I cannot see why it will not rise, although at a very less rate than that of water that is close to the firebox sheet.

INSPECTION PITS AT ENGINE HOUSE.—An adjunct to terminal facilities is now being advocated by those giving the matter close attention, and that is having what is known as an inspection pit placed where engines bound toward the roundhouse will pass over it. This pit should be shallow, simply deep enough to permit men to walk under the engine and enable them to examine all its parts. The object of the pit is that engines will be stopped over it on their arrival and will be thoroughly examined by competent inspectors, and in a busy time this is quite an advantage in helping the movement of engines. Many times an engine reaching this pit will be found on inspection to have but a few nuts loose here and there, or in need of some slight repairs that can be made right on the pit; the engine then passing along through its different operations, goes on the table to be turned and is ready for a return trip. This saves its going to the house at all and is an advantage at a busy terminal in busy times when power is scarce.—*R. D. Smith before the New England Railroad Club.*

A CAR WAS BLOWN FROM THE TRACK of the Union Pacific Ry. near Lone Tree Creek, Wyo., 30 miles west of Cheyenne, on October 19. It was the caboose of a work train bound for Hermosa Junction and carried about 40 laborers. The wind threw the car from the rails, breaking its coupling, and it dropped 30 feet down the embankment. The car was entirely broken up and six men were killed.